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Vol. VI No. 1

Proceedings *of* The Society of American Foresters

1911

THE SOCIETY OF AMERICAN FORESTERS

OFFICERS AND COMMITTEES FOR 1911

OFFICE OF THE SOCIETY

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PROCEEDINGS
OF
THE SOCIETY OF AMERICAN FORESTERS

VOL. VI 1911 No. 1

CONTENTS

WASHINGTON, D. C.
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MAY 1, 1911

Copies of the Proceedings may be obtained from the Secretary for 50 cents each number.

PROGRAM OF MEETINGS

April, 1910, to March, 1911

November 17, 1910.	Open Meeting. Forest Experiment Station Work with Special Reference to the Streamflow Study, by Carlos G. Bates.
January 12, 1911.	Open Meeting. Tropical Woods as Substitutes for Northern Conifers, by Hugh M. Curran.
February 2, 1911.	Annual Executive Meeting.
February 9, 1911.	Open Meeting. The Rise of Forestry in the United States, by Gifford Pinchot.
February 22, 1911.	Open Meeting. Personal Recollections of a Forester, by Gifford Pinchot.
March 2, 1911.	Executive Meeting.

PROCEEDINGS

OF

THE SOCIETY OF AMERICAN FORESTERS

The Society is not responsible, as a body, for the facts and opinions advanced in the papers published by it.

VOL. VI 1911 No. 1

REPORT OF THE SECRETARY FOR THE YEAR ENDING DECEMBER 31, 1910

SUMMARY

Membership Roll

One honorary and eleven active members were elected during the year. The death of one active and one associate member, and the resignation of three active members makes the present membership as follows:

Active	154
Associate	45
Honorary	1
Total	200

The number of active members now resident in Washington or vicinity is twenty. The active membership is distributed geographically as follows:

District of Columbia		20
Northeastern States		
Maine	3	
New Hampshire	2	
Vermont	1	
Massachusetts	4	
Connecticut	5	
New York	1	
Pennsylvania	6	
New Jersey	2	
		24

Southeastern States		
North Carolina	2	
Georgia	1	
Florida	1	
		4
Lake States		
Michigan	3	
Illinois	1	
Wisconsin	7	
Minnesota	3	
		14
Northern Rocky Mountains		
Montana	9	
Idaho	4	
		13
Central Rocky Mountains		
Colorado	6	
Utah	5	
Nebraska	1	
Kansas	1	
South Dakota	1	
		14
Southwestern States		
Arizona	5	
New Mexico	10	
		15
North Coast States		
Washington	5	
Oregon	17	
		22
California and Nevada		18
U. S. Possessions		
Philippine Islands	3	
Hawaii	1	
Alaska	1	
		5
Canada		5
Total		154

Publication of Proceedings

Volume V, Number 1, of the Proceedings of the Society has been printed and distributed.

Important Constitutional Changes

The Constitution was amended in seven important particulars by a letter ballot of the Society, while a further amendment was lost only through the failure to secure the required three-fourths majority for one of two optional plans submitted before the Society. The amendments embody the following changes:

Meetings

1. Provision for an annual meeting for the transaction of business and the presentation and discussion of professional papers at a place and on a date to be designated jointly by the Executive Committee and the Committee on Meetings.
2. Executive and open meetings not to be on a schedule; executive meetings to be held at the call of the President, or, in his absence, of the Secretary; open meetings to be held as directed by the Committee on Meetings.
3. Provision for "special meetings" struck out.
4. Quorum reduced from nine to seven active members.

Publication

5. By specifying that publications shall be free of charge to all active and honorary members, the free distribution of the Proceedings to associate members is discontinued.

Dues

6. Annual dues reduced from five to three dollars.
7. New members to pay dues for the year in which they are elected, even if elected during the second half of the year.

The distribution throughout the country of the active members, often in groups of fifteen or more within a restricted region, suggested the idea of a division of the Society into "Sections." To determine the attitude of the Society on this point, a circular embodying this, among other proposed amendments, was sent to all the active members. The responses indicated strong sentiment in favor of the "Section" plan in general, but revealed considerable opposition to the proposed amendment, chiefly on the following grounds:

(1) It admitted a new class of "local members," not otherwise provided for in the Constitution.

(2) It made possible the organization at forest schools of sections with "less than seven" petitioning active members. Since only active members of the Society would be empowered to act as chairmen and secretaries of Sections, the latter, when located at forest schools, would be practically under Faculty control.

An alternative amendment was then prepared by members of the Executive Committee, embodying the principle of "Associated Forestry Clubs," and submitted, along with the original "Section" amendment, for a vote of the Society. By this plan, a local forestry club could become associated with the Society, subject to the approval of the Executive Committee, upon the petition of two or more of its members who were also active members of the Society. The members of the local club were to have no connection individually with the Society, but only as a club. The vote on these alternatives stood 28 for sections and 37 for clubs, both amendments lacking the three-fourths majority required to pass.

Important Business

By a unanimous vote of the Executive Committee, the Society has agreed to contribute annually, for five years (from 1908 to 1912), the sum of $25 toward the publication of the International Forest Bibliography. The International Association of Forest Experiment Stations has been informed of this action, but no directions in regard to payment having been received, the payments for 1908, 1909, and 1910 have therefore not been made.

Deceased

During the past year the Society lost by death two members, one active and one associate. Mr. L. C. Miller died last summer at Denver, and Prof. W. H. Brewer at New Haven.

E. H. FROTHINGHAM,
Secretary.

ANNUAL REPORT OF THE TREASURER, MARCH 18, 1910, TO JANUARY 31, 1911

Summary

Receipts

Balance from previous Treasurer	$399.67	
Annual dues	658.00	
Sale of Proceedings	155.75	
Interest on bank deposit	17.78	
		$1,231.20

Disbursements

Printing and stationery	$484.38	
Postage	46.85	
Typewriting and mimeographing	22.50	
Express and freight	7.47	
Refund of dues, paid when not owed	30.00	
Rent of Cosmos Club hall	15.00	
Miscellaneous	1.15	
	$607.35	
Balance on hand	623.85	
		$1.231.20

Assets

Cash on hand	623.85
Dues owed for 1908	10.00
Dues owed for 1909	65.00
Dues owed for 1910	155.00
Dues owed for 1911	456.00
	$1.309.85

Liabilities

Contribution to International Forest Bibliography	$125.00

S. T. Dana.
Treasurer.

Audited and approved by—
W. W. Ashe and
F. W. Besley,
Auditing Committee.

REPORT OF THE COMMITTEE ON NEW WORK

We, as your Committee appointed "to consider a plan for broadening the activities of the Society through taking a definite position on vital national questions within the field of forestry," have the honor to submit the following report and recommendations:

It is our opinion that the time has fully arrived for the Society to take, as a body of professional foresters, a definite and public position on vital national questions within the field of forestry.

We believe, that in this way the Society will greatly increase its own achievement, will arouse and maintain the active interest and support of its membership, and will contribute materially to the advancement of forest conservation in the United States.

The plan we have the honor to submit is as follows:

1. That as urgent national questions arise in the field of forestry, the Society, when asked for a statement of its position by any organization or individual who can properly make such request, as for example,—by members or committees of Congress, by State or Federal officials concerned with forest resources, or by the representatives of national industries dependent mainly upon the forest,—shall draw up a statement of its position as a body, and give this statement such publicity through the daily or periodical press as is consistent with dignity and effectiveness.

2. We suggest that the following procedure be observed by the Society in such cases:

Upon the receipt of a request for a statement as to the position taken by the Society upon any question, affecting the forest, the request shall be referred by the President to the Executive Committee, for recommendation to him whether both the question raised and the nature of the request justifies the Society in a public declaration of its position. Should the recommendation of the Executive Committee be favorable in both these particulars, the President shall appoint a committee composed, in his discretion, of three, five or seven members of the Society, which committee shall be instructed by him to draft a statement of what it believes should be the position of the Society upon the question raised. Upon the completion of the draft, the committee shall forward it to the Secretary, who will submit a copy of the statement to each member of the Society for his written criticism. As criticisms are received they will be transmitted by the Secretary to the Committee charged with the preparation of the statement. The Committee will then prepare a final report embodying, so far as it deems advisable, the criticisms of the original draft made by individual members of the Society. Upon the completion of the final report, the Committee will forward it to the Chairman of the Ex-

ecutive Committee, who will lay it before the Society for action at the first Executive meeting after its receipt. In the event that the Society approves the report, a copy will be sent to each member of the Society and to the individual or organization by whom the request for the report was made, and will be given publicity in the published Proceedings of the Society and in the daily or periodical press, or both, as the Executive Committee may deem advisable, by which Committee the report will be made public, as a statement of the position taken by the Society of American Foresters as a whole. As new questions arise upon which the judgment of the Society is asked, they may be referred by the President to the Committee charged with the preparation of reports upon questions previously raised, or to a new Committee appointed by the President, as he may deem advisable.

3. Among the national questions in the field of forestry which we believe should be considered under the foregoing plan, are the following:

The relation of forests to streamflow.
The principles of forest taxation.
Public regulation of private forests.
The essentials for training for the profession of American forestry.
Principles and organization for effective forest fire patrol.
Conditions which justify State and Federal Forests.

In the judgment of your Committee, statements of the position of the Society on these or other forest questions should be brought to the attention of similar professional bodies in other countries, and also of the forest departments of foreign Governments. This will institute a productive interchange of ideas between the Society and members of the same profession in other lands, and thus aid to advance the cause of American forestry.

To sum up, your Committee believes that the plan proposed offers tangible and important opportunity for this Society to act effectively and as a unit, in giving expression to its convictions, and to promote the practice of forest conservation in the United States. We believe that by far the most serious lack at present in the field of endeavor of the Society is the failure of provision for a method by which it may focus the combined knowledge and experience of its members upon vital public questions affecting the forest.

O. W. PRICE, *Chairman.*
F. G. PLUMMER.
H. S. GRAVES.
FILIBERT ROTH.

In Memoriam

FRANK JAY PHILLIPS

BY DR. CHARLES E. BESSEY

Frank Jay Phillips was born in Grandville, Michigan, September 25, 1881, and died in Lincoln, Nebraska, February 13, 1911. He graduated from high school, and later from the Michigan Agricultural College (B. Sc. in 1903), and afterwards from the University of Michigan, with the degree of Master of Forestry (1906). A year later he was elected Professor of Forestry in the University of Nebraska, a position which he held until his death.

His practical training began when a boy, in the experience gained in and about his father's sawmill, where he learned much about lumbering and marketing. This was continued in the United States Forest Service with which he had close connection from 1903 when he first began to spend his vacations in the field. Thus since 1903 he has studied in succession, sand dune problems in Michigan and Indiana, the forest lands in northern Minnesota, planting problems in the sandhills of Nebraska, the sand dunes of the Columbia River in Washington and Orgeon, the eucalypts in southern California, the loblolly pine in eastern Texas, forest planting problems in Illinois, the pines of northern Nebraska and the Black Hills, forest planting problems in Nebraska, Kansas, Colorado and Wyoming, the National Forests of the Southwest, etc., etc. Here is a mass of work that seems quite beyond the possibility of accomplishment by one man in the time allowed him, and yet those under whom he worked said of him that in all his work *he got results.* In fact this was his reputation in the Forest Service; he was a man who could be trusted to accomplish what he set out to do.

It was during one of his assignments to work in Nebraska that I met him while he was working on the Dismal River Forest Reserve. In company with Senator Burkett I visited the Reserve in order to see what was being done in the way of tree planting, and the growth of seedling trees. He was working on the Reserve in his usual vigorous fashion, and I remember that Senator Burkett was then greatly impressed with the promise of the young man, in which I fully agreed with him.

Upon the resignation of Professor Frank G. Miller, who had held the chair of Forestry in the University, Chancellor Andrews asked me to find

a man to fill the vacancy. It did not take long for me to make up my mind to secure young Phillips whose acquaintance I had made in the Sand Hills, and in September, 1907, he came to the University.

Professor Phillips came to us a young man, full of youthful hopes, and with the far outlook of the young man. He brought his bride with him—one who had been his companion in his studies, and who shared in his plans and hopes. He came with the warm regard and best wishes of his professional friends, and their confident prophecies of a successful career.

For three and a half years he worked with us and for us, building in the University a strong and vigorous department. He applied himself so unremittingly to his task, that he was rarely seen in social circles, and was a stranger to many of his colleagues. He was a student, a scholar, an investigator. Brilliant, far beyond the average of men, he was splendidly equipped for his work by his college and university training, and his later service in the field. By his enthusiasm, and the attractiveness of his personality he gathered about him a body of earnest, enthusiastic, loyal students who felt he was indeed a worthy leader. Trusting him implicitly they followed where he led, and no task was too hard, no requirement too severe for these enthusiastic and earnest students.

In these few years he brought together a splendid equipment, crowding and overflowing the rooms of the department with an orderly array of books, apparatus, implements, tools, and illustrative material, while planning still larger things for the future in additional courses of advanced study intended to still better prepare his students for their work as professional foresters. He neglected no details in any part of his daily duties. He worked early and late. He never relaxed. He worked every day and late into the night. He worked continuously, without vacations, spending his summers in the field with the Forest Service, or in preparation for the coming year's duties. He wore out his life in the service of the University, and his tired body fell an easy victim to disease, and his exhausted brain yielded to the breaking strain.

With hosts of admiring friends in his profession prophesying a brilliant career—with a future that seemed to us all to be full of certain promise—his life suddenly went out, and naught is left us but a memory of what he was, and still more of what he promised so certainly to be.

His life with us was like that of a meteor which flashes brilliantly across the evening sky, leaving a golden path to mark where it had been, then fading into darkness.

Friend, comrade, colleague, fare you well.

WORKING PLANS FOR NATIONAL FORESTS OF THE PACIFIC NORTHWEST

BURT P. KIRKLAND

(*Contributed*)

It is not the purpose of this discussion to take up the question of reconnaissance in this region. It is assumed that, preliminary to the preparation of any working plan, the necessary data as to stand of timber, distribution of age classes, soil quality, etc., have been collected. It may, however, be stated that the method known as "the new reconnaissance" is wholly unadapted to the dense forests of the Pacific Coast, and nothing better than the strip system modified to provide for securing as full data as possible concerning age classes, soils, site quality and types has been, or is likely to be, devised. Running once through a forty is sufficient for working plan purposes. Complete information as to the reconnaissance methods used can be secured from the reconnaissance instructions issued by the District Forester, for the west slope of the Cascades, in District 6.

It is also assumed that it will be taken for granted that an approximately sustained annual yield management is the one to be adopted, and that it is desirable to get on this basis as soon as possible, whether doing so involves reducing or increasing the present cut. It is hoped that the principle that storage of decadent stands now does not mean increased cut later is fully understood. As it is now universally conceded by all familiar with the region that clear cutting must be the method used, it is scarcely necessary to mention this point. The discussion which follows would not be clear if it were not borne in mind that it applies to even-aged forests cut under a clear-cutting system, which is the condition of the Pacific Coast Forests as far as Douglas fir. the leading species, is concerned.

The Unit of Regulation or Working Circle, and its Subdivision into Smaller Areas for the Purposes of Description and Working Plan Control

The proposition has sometimes been advanced that the unit of regulation in District 6 should be the entire District, or at least that part of the District west of the Cascades, i. e., that an amount of timber should be cut in the District such as all of the Forests could bear, but cut possi-

bly from certain Forests while on others little or no cutting took place. This idea has been pretty well abandoned, but it is necessary to note it in passing. It would be impracticable, because it would require superhuman intelligence to regulate the cut by so large a district, and the inevitable consequence would be that over-cutting for the entire district would take place at times. No regulation of the cut, even approximately exact, can take place except through the preparation of local working plans which can be revised from time to time as the need arises, without disturbing the management of other areas. If the regulation of local areas is properly conducted, the regulation of the Forests of the entire District follows as a matter of course. This proposition has, I believe, been advanced because the practice of fixing a cutting budget for a State based on what the local forest units would produce has been confused with regulation by the entire district, as aforesaid. It is true that temporarily regulation by Forests, or watersheds, has its disadvantages, since owing to the inaccessibility of some Forests it will take some time to get them up to their proper cutting limit, and in the meantime, if the cutting limit of other Forests is held down, the revenue on the entire District will be less than it should be if regulation by the District were adopted. However, by making proper relative stumpage prices it will be a matter of only a few years before a proper amount of cutting takes place.

If there were such a distribution of age classes on the various Forests as left some of them with all over-mature timber, and others with immature timber, there would at first thought be a reason for regulating by the District, or at least by several Forests together. A little consideration shows, however, that any working plan for one of these smaller areas may provide for light cutting if the timber be immature, or possibly no cutting; and if it be over-mature, may provide for removing surplus stock. As a matter of fact, it is probable that such a distribution of age classes does not exist in any Forest unless it be on the Siuslaw Forest in Western Oregon. It does not exist in Washington Forests, except that all of them have a preponderance of over-mature timber.

To others, the regulation of the cut by each National Forest seems the proper method to pursue. This is, however, by no means the best unit of regulation, because National Forests are not fixed units of administration, and if all of the cutting takes place on one part of a National Forest and none on the other parts, future administrative divisions will leave some Forests over-cut and others under-cut, with consequently less satisfactory conditions of administration. There is only one suitable unit of regulation which should be used on National Forests, and that is the large watershed, or a combination of several small watersheds. Consider-

ing each watershed, or group of small watersheds, as a unit of regulation has the following advantages.

(*a*) Since if an approximately equal amount of cutting takes place on any watershed each year, followed by regeneration of the cut-over areas, the result will be stable forest conditions on the watershed, it follows that any influence that forest conditions have on streams will be uniform, and tend to maintain equable stream flow. On the other hand, regulation by the District, or the Forest, is likely to strip some watersheds within 10 or 20 years, with a resultant adverse influence on stream flow conditions. The barren watersheds resulting in some places would surely be a poor object lesson in the practice of forestry, and people who had been accustomed to using such places for camping, fishing, hunting and other recreative purposes, would be deprived of their favorite pleasure ground, and would without question make vigorous objection to this method of cutting.

(*b*) If a valley were all cut over in a short time, the regenerated stand would be practically of one age class, and uniform throughout the valley. In case of fire, or serious insect or fungus attack, the damage done would be far greater if the valley bore only one age class, since resistance to fire and disease varies with the age of stands. If damage occurred while an even-aged stand were young, all would be lost; if it were old, much would also be lost on account of the difficulty of utilizing so much at once.

(*c*) In this Forest, the local forest population, except miners, will be almost entirely dependent on the cutting of timber for a living. In other regions where there are large agricultural areas, a permanent local lumber supply is useful, but not absolutely necessary, in order to maintain industries other than lumbering. Here the cessation of the lumbering industry will mean the removal of the entire local population, together with the resultant abandonment of their homes. This is in itself a sufficient reason for regulating the cut by watersheds. If an annual sustained yield by watersheds is adopted, the population will be permanent, and permanent roads, homes, schools and other advantages of civilization will result. On the other hand, the stripping of first one watershed and then another would result in the creation of a transient population entirely lacking in desirable characteristics, except a facility of exploitation by others. I know of no example of a temporary industry which has had other than a deleterious effect on the persons engaged in it. It is clearly within the function of any government managing forests to consider this feature.

(*d*) Furthermore, unless regulation by watershed is adopted, the financial results of Forest management will be decreased, for the reason that

a permanent transportation system cannot be maintained where timber is the only resource and no old timber exists, with the result that profitable thinning in the stands following the present ones cannot be made until much later than should be the case. Small areas of timber damaged by fire, insects, or other injurious influences, can not be removed. As a result much valuable material will be lost which could be saved if a sustained annual yield regulation were adopted with its inevitable accompaniment of permanent transportation. It will not pay to put in transportation for the removal of thinnings or small areas of injured timber alone. It is evident that in case of insect injuries this might have very serious results, in addition to the loss of small amounts of material first injured. In the case of thinnings, not only will material which might be utilized be lost, but the final yield of stands affected will be reduced. Some may say that thinnings can not be made anyway. To this it may be answered that they are already possible for railroad ties and pulpwood in stands 40 or more years old.

Regulation of cut by watersheds does not in any degree prevent necessary action toward the reduction of surplus stock wherever it occurs, or the taking of any other step toward the improvement of the Forest. If a watershed should be found to bear only young stands, of course no cutting can take place at present, but it will be advantageous to begin cutting as soon as these stands are financially mature. On the Snoqualmie Forest no such watersheds exist, and there is nothing whatever in the way of regulation by watersheds except the temporary inability to cut now on account of lack of transportation facilities. This condition will pass within five years, or less.

I conclude, therefore, that cutting on one Forest can properly be influenced only to a very limited degree by the state of others, and furthermore, that as far as possible, regulation of cutting should be by watersheds within the Forest instead of by Forests. Regulation by watersheds attains all the desirable results given by regulation in larger units, except that it may possibly put off for three or four years getting the Forests to their cutting limit. It gives none of the undesirable results which regulation by larger units will.

It is very essential, therefore, to declare unreservedly for regulation by large watersheds, or groups of small watersheds. By this, I mean areas which are large enough to support a wood industry such as a sawmill, or a pulp mill, permanently, without outside supply. There are watersheds so small and so isolated from other forest areas that they cannot be so regulated, but these are the exceptions. These exceptions will usually have to be cut over when adjacent timber outside the Forests is cut, and

regulated under a periodic sustained yield management, though they will usually form part of some of the larger units of regulation. It will be advisable to make watersheds of less than 50,000 acres in extent, although capable of being self-sustained, working sections to be grouped together into working circles. For example, on the Snoqualmie Forest it is planned to make four working circles for the entire Forest. These working circles will, in some cases, consist of two or more working sections, due to the timber coming out in different directions and to be utilized by different sawmills. The aim will be to make each watershed a permanent source of supply for one or more manufacturing plants, thus enabling the highest character of permanent plants to be built. This will be particularly favorable for pulp mills and sawmills of the future, which, where raw materials warrant, will consist of central lumber plants with auxiliary plants for utilization of by-products. To be worked as a separate unit in this region any watershed should preferably be capable of yielding at least 5,000,000 ft. B. M. per annum, since sawmill plants of less size than this can not be expected to be of very high efficiency for large timber, though certain kinds of plants utilizing not more than 2,000,000 feet a year may be successful. On any watershed which will not do this, the timber must either be sold to some logger, who will ship the logs to existing mills or to the general market on tide water, or a mill must be established which will cut off the watershed in a short period, with the expectation that cutting on some other watershed in the group comprising one working circle will follow after the first one is cut off. Where a mill has only 10 to 20 years' cut before it, not so good a mill can be built as where the timber supply will be permanent, and less efficient manufacture and more waste may be expected. This method of regulating will be particularly favorable to pulp mills which require the investment of more capital than sawmills.

The Block

Having decided on the working circle to be placed under a single working plan, which area will usually contain from 50,000 to 300,000 acres, it is necessary to divide this for purposes of management into subdivisions. Probably the best term to use for the primary division of the working circle is the block. The block will consist usually of a single smaller watershed, forming part of a group, or part of a larger watershed in the working circle. Blocks will generally be from 5,000 to 50,000 acres in extent, and receive local names from the streams which drain them or some other local circumstance.

The Compartment

It will further be necessary to divide each block into smaller subdivisions, which are best termed compartments. Compartments should be bounded according to topography, and distribution of age classes. They will vary from 50 to 1,000 acres in extent, each being usually of suitable size for a timber sale area, or part of a timber sale area. Since in steam logging it is easier to pull logs up hill than it is down, compartments based on topography should be bounded by streams rather than divides, except in cases where divides are too sharp to be crossed by logging roads, in which case these form proper division lines. The streams also form the best boundary lines, because they can be definitely located on the ground as well as on maps. The European practice of bounding compartments by roads, or rides, in order to permit the removal of forest produce from each compartment without disturbing others, can not be followed in this country, since such division lines are lacking. Since logging is carried on by railroads, on extensive areas, it would be impracticable to use them if they did exist. Probably in some cases firelines along ridges will form compartment boundaries within a few years. It should be noted, also, that the European practice of making compartments from 5 acres or less to 50 acres or more in extent should not be followed, as we will not reach this intensive stage of management for years to come. Here where forestry must be extensive, this would merely increase the cost of administration without giving any compensating desirable results. Since extremely intensive forestry will not come until natural resources are so fully utilized as to make the standard of living low, and labor correspondingly cheap, which we hope will be a remote contingency, the first working plan prepared here for any area should lean toward making the compartment as large as possible rather than small. They can then later be subdivided, if necessary. Compartments should be numbered serially for each block, and when any further divisions occur, the subdivisions can be designated as compartments by adding letters to the serial number which the compartment had before subdivision took place.

The Choice of Rotation

The next question that should be determined in forest management here is the question of the length of rotation which should be used. In opening this discussion it is sufficient to say that a rotation based on the financial rotation, possibly modified somewhat towards the rotation of the highest income, is no less adapted to government forestry than to pri-

vate forestry. The only reason for having a possibly longer rotation in government than in private forestry, is the fact that the government can secure a lower rate of interest, especially on long term loans, than individuals or corporations can. If special needs exist for large size material, they will warrant high enough prices for this class of material to make the long rotation necessary to grow it the financial rotation for limited areas on which it is to grow. If the Government has no other use for money derived from business-like administration of the Forests, it can profitably be applied to other conservation measures, such as the purchase of land for forest purposes, the development of waterways and water power, and in other directions too numerous to mention. I shall proceed, therefore, on the assumption that the financial rotation is a proper one to apply in Government forestry just as in private.

In the absence of reliable yield tables, and with uncertainty as to future prices, it is difficult to apply this method at present except to stands nearly mature. However, by comparison with similar species in other countries, and by use of the crude yield tables which have been prepared for Douglas fir, we can arrive at a reasonably close estimate of the length of rotation most desirable. In choosing the financial rotation it is well not to overlook that the result of a constant fall in interest charge which takes place in all countries as the density of the population increases and natural resources become more closely utilized, will have a tendency to lengthen the rotation. Owing to lack of definite information, it seems desirable to assume a fairly long rotation for the present, at least. The demand on the Forests is not now sufficient to warrant over-cutting or any special tax on their resources. For this reason I believe a rotation of 90 to 100 years should be assumed for the present, and probably it would be better to assume the latter length. In the upper slope type a still longer rotation will have to be used to produce useful material.

In financial calculations, 3% interest is believed to be a fair rate in Government forestry. Annual expenses have usually been assumed much too low, for the reason that they have been worked out on the basis of appropriations for the National Forests. Not only are these appropriations too low at present, but the large proportion of land incapable of producing commercial forest on the National Forests, has been overlooked. Obviously this barren land, probably amounting to at least 50% of the area, will yield no income, and nothing should be charged up as expended on it. This has the effect of doubling the expenditure on the forest producing land. In all probability the expenditure after alienated and barren lands inside Forest boundaries are eliminated from consideration, amounts already to 4 or 5 cents per acre, and this must be greatly in-

creased. Therefore, 20 cents per acre should be assumed for annual expenses. Five dollars per acre should be assumed as the average cost of formation. Seeding will be less, and planting more than this, but it perhaps represents a fair average. Future stumpage may conservatively be assumed to be worth all the way from $5 per M board feet for 40-year old stuff, up to $10 or $12 for 100-year old. We may also assume a yield of thinnings every decade from the fortieth year on. Calculating with the above assumptions, and the yields shown by T. T. Munger's yield table for Douglas fir on quality I* soil, a rotation of 90 to 100 years is indicated for Government forestry.

As applied to stands now being planted, these calculations are of interest only in the realm of speculation on future conditions, but they have a necessary place in forest management on the National Forests, because it is necessary to determine the probable length of rotation in order to know how long we must make the present virgin stands furnish the cut.

In this connection, it is well to call attention to the fact that in many working circles it will not be necessary or advisable to assume that the first rotation should be 100 years, if that is the theoretical length of rotation assumed to be correct. This will be true for areas where stands are decadent. For example, the Stillaguamish watershed on the Snoqualmie Forest, now bears, almost exclusively, old stands of hemlock with cedar in mixture. These old stands, though on good forest producing soil, contain an average of only about 40,000 ft. to the acre, whereas a Douglas fir stand 100 years old ought to contain from 50,000 to 80,000 ft., or say an average of 60,000 ft. to the acre on the same area. It is evident, therefore, that if we extend cutting of the old stand over 100 years, as soon as cutting begins in the next rotation, cutting of an equal area then would produce an increase of at least 50% in the volume production. I think it is a safe principle to go by, that it is legitimate to cut as much as we can at present from the Forest, provided we do not take so much that at some time in the future the cut will have to be reduced. This, it seems to me, is taking care of the future to a sufficient degree. Referring to table No. 4 in the circular on the growth and management of Douglas fir, by Mr. Munger, we find that 60-year old stands have 41,000 board feet to the acre. It appears, therefore, that if we cut over the entire area of quality I land in this valley in 60 to 65 years, following the cutting each year by regeneration with Douglas fir stands, that after the old stand is removed it will be possible to continue cutting immediately in the oldest of the young stands, removing the same volume of timber annu-

*Forest Service Circular 175, "The Growth and Management of Douglas Fir."

Wherever volume regulation is applied it should be applied only to large watersheds, or groups of watersheds, as has already been discussed, and not to Forests, or larger areas.

Regulation by removing an amount equal to the possible annual growth. Since we do not yet know very much about either the actual present or possible growth, over the entire Forest, it is not possible to base rational regulation of cut on this factor. It is sometimes useful to use it as a check, however. Thus one may compare the results which it is calculated can be obtained by area regulation with the possible growth of the Forest calculated from yield tables according to quality of the soils for forest purposes.

Regulation by Area. For the following reasons, regulation by area, with volume check, is believed to be the best method of regulating the annual cut. (1) Neither formula methods, volume regulation, nor reroval of the possible annual growth secures a proper area distribution of age classes. They simply give annual sustained yield in this rotation, while area regulation secures proper age class distribution in the next rotation, and by careful selection of areas to be cut, approximately annual sustained yield in this. (2) It will be easier, and involve less financial loss, to start area regulation now instead of waiting until by overcutting in certain places the distribution of age classes becomes still more abnormal than at present. The data for regulation by area can be obtained much more accurately relative to the expense than for volume regulation, as age classification can be obtained correctly without cruising too large a per cent. Volume estimates can not be obtained with as much accuracy. Therefore, useful provisional plans, based on the area distribution of age classes, can be prepared as a result of only a season's work of one or two men on a Forest. Such plans are of only temporary use, however, and will not be discussed here.

Presentation of Working Plan Data

Maps. Before the data covering any area to be put under working plan can be handled intelligently, it must be put in concise form. This is best done by putting it all on maps, and relying little on a written report. The maps necessary are best prepared by first making an accurate tracing of each township involved, on a scale of 4″ to the mile, showing all topographic and other permanent data, and from this making a negative from which as many whiteprints as are needed may be prepared. For each township the following maps are necessary. (1) A whiteprint plat bound by the right-hand margin, showing alienated lands and their pres-

Provisional Wo

ALLOTM

BLOCK.	TYPES.	Total area of type.	Age classes.	Total areas of age classes 1910.	Total present volume. M ft.	Av pr vol a M
North Fork Skykomish	Lower slope	26990	1–20	340		
			Decadent	3225	161250	
			200+	23425	1171250	
	Upper slope	48385	200+	48385	241925	
	Barren	20275				
	Total for Block.	95650		75375	1574425	
South Fork Skykomish	Lower slope	15225	Decadent	3275	131000	
			200+	10940	437600	
			Burns	1010		
	Upper slope	38805	200+	38060	190310	
			Burns	745*		
	Barren	8489				
	Total for Block.	62519		54030	758900	
Beckler River	Lower slope	7545	1–20	70		
			200+	7475	523250	
	Upper slope	24410	200+	24410	122050	
	Barren	3890				

ent ownership. (2) A plat bound by the left-hand margin, showing special uses, including rights of way, etc. (3) A plat bound by the right-hand margin showing block and compartment divisions, age classes of timber, in colors, stands per acre and total stands for each forty, or compartment in figures. The age classes used should be 1-20, 21-40, 41-60, 61-80, 81-100, 101-200 years, 200 years thrifty, and 200 years plus, decadent. (4) A plat bound by the left-hand margin showing in colors the different soils, site quality, and type classification. A complete description of the last two maps is given in the reconnaissance instructions for District 6.

Tables. After the maps are prepared, the data shown on them should be summarized in tabular form so far as it influences the prescriptions in the working plan. These prescriptions may best be made part of the same table. Table I shows the form adopted on the Snoqualmie Forest for tabulating the results of a provisional working plan prepared in 1909 as a result of a general superficial reconnaissance. The same form, with few changes, is adapted to detailed plans. It has already been mentioned that regulation chiefly by area is equally adapted to provisional plans prepared as a result of superficial reconnaissance pending the gathering of more accurate data, and if the same form is used in each case, the revision of provisional plans can be most easily made. The table is for the most part self-explanatory, especially as to the presentation of the data on which regulation is based.

Following the 9th column the area prescribed to be cut is shown under allotment to periods of which there are five, of 20 years each. Of course only recommendations for the first period are expected to be carried out in detail and these revised at the end of ten years. The object of the columns under periods two to five, inclusive, is to show that after the amount recommended to be cut during the first period has been taken, there is sufficient area remaining to provide an approximately annual sustained yield throughout the remainder of the first rotation.

It should be particularly noted that in the area allotment as carried out in this plan, no attempt has been made to assign any particular tract to any period except that the cutting is to be located in certain blocks. The recommendation, therefore, consists in stating that a certain total area should be cut in each block if possible, during each period. The only restriction is that the cutting should be located in the 200 plus decadent age class, where it exists, or failing that, in 200 plus thrifty. Of course where it is possible to locate the cutting more precisely it should be done, but no attempt should be made to prescribe cuttings that can doubtfully be carried out, and thereby make the plan unworkable. Since

transportation is not yet fully developed in many cases, it is expected that the actual location of cutting operations will have to be determined upon later, subject to the above requirements, which should be insisted on absolutely. The stock map will show on what areas cutting may properly be located. As in most cases there is a considerable range of choice, the advantage of having the exact choice of cutting location open is manifest, since it is thus possible to satisfy the demands of purchasers much more fully.

The establishment of mills should not be permitted unless they can be taken care of for practically an indefinite period. In the early part of the first period, on account of the lack of transportation facilities, it may not be possible to cut to the safe limit in some watersheds, in which case over-cutting in other districts sufficient to recompense may be allowed, thus conceding partial regulation by the Forest temporarily. In working circles which have to be over-cut now, cutting can later be reduced providing the present cutting consists of logging in small isolated blocks, which naturally in themselves only form timber sales of four or five years' duration. The cut in districts which are not cut to their limit now can be correspondingly increased so that within the first 20-year period the desired amount can be cut in each working circle if care is taken to do this.

The following principles should be followed in the allotment of areas to periods. Since it seems to be a safe assumption that denuded burns can be restocked within the next 20 years, the regeneration of all these burns should be placed in the first period. Since if regenerated during this period these burns will come in the oldest periodic age class in the next rotation, they take the same place in the plan as cutting would do. Consequently, the area to be cut during the first period will be reduced in each block by the amount of burned area not reforesting naturally to be regenerated. The result will be that the area recommended to be cut during the first period will be less than the area to be cut during the second and succeeding periods. This method is correct both from the standpoint of furnishing a greater timber supply when the shortage in supplies may be expected to come, and also from the standpoint of securing the proper distribution of age classes during the first rotation. It must also be remembered that from a financial standpoint this will be best, since during the next 20 years price increment in old stands may be expected to be greater than volume increment in young stands.

Under a system of regulation by area where there is so much difference in the producing capacity as exists between lower slope and upper slope types in this region, it is necessary to give the poorer areas less weight.

Here, therefore, one acre of lower slope is considered to be equivalent to ten acres of upper slope. For more detailed plans each type will have to be divided into three qualities, and each quality given its proper weight. Owing to its inaccessibility, and to the probable necessity of using the selection method in the upper slope type, all upper slope areas should be thrown into the later periods. Actual cutting in the upper slope will doubtless begin somewhat sooner, in some cases at the time thinnings are necessary in adjacent young lower slope stands following cuttings made at an early date. Hence, in the first period, burns and poorly stocked decadent lower slope areas should be treated. In the second and third periods, cutting may be expected to continue in the decadent lower slope stand, with some cutting in upper slope adjacent to lower slope cut in the first period and ready for thinning, and in the fourth and fifth periods 200 plus thrifty, and stands now young, and remaining upper slope areas may be expected to be cut over. Withholding the main cut in upper slope till the last periods of the first rotation is justified silviculturally on account of deterioration being less rapid there. In order to make the plan uniform, the estimated final yield on the upper slope areas should be only the yield these areas will give besides leaving the necessary amount of young and thrifty timber for the next cut. Owing to so large an area of the Forest being in the decadent class, it is doubtful whether very much surplus stock exists. Therefore, no steps toward the disposal of the surplus stock need be provided for in the first period. It does not seem advisable to attempt to dispose of it until the second period, at least. Reasons have already been given why it is desirable to hold until the second period at least as much of the timber as can be held without defeating the attainment of a proper age class distribution during this rotation. Whenever it becomes possible to prescribe specific areas for cutting only a slight alteration in the form of the plan will be necessary to provide for cutting in certain compartments. The alteration will consist only in adding an additional column for making specific compartments before age classes, and also naming compartments under allotments to periods so far as they are to be cut over during the first period.

Execution of Working Plans

Location of Sales. As already indicated under the explanation of the working plan, no attempt is made to prescribe definite location of sales. It is expected only that sales will be located in the most decadent timber. They should also be located on the poorest stocked areas so far as possible, since the removal of a smaller amount of volume from these areas will give

sufficient cut-over area to form the older age classes in the next rotation. The heavy stands retained will give much greater price increment per unit of area. In short, the Forest Service should not blindly follow the wishes of purchasers in selling timber, but should make sales only where the condition of the timber and considerations of a proper distribution of cutting make them advisable. It is doubtful whether the regulations in this respect should not be entirely changed, and all sales initiated by the Forest Service, paying attention to the desires of purchasers only in so far as they do not conflict with the needs of proper management. Owing to the large area of our sales, it is seldom possible to pay much attention to cutting direction. Where any choice in the cutting direction is possible, however, the cutting should proceed toward the direction from which comes the prevailing wind, both to prevent windfall, and allow seeds to blow upon the area as much as possible, and thus to a certain extent provide for natural reproduction. In the mountains it is scarcely possible to exert much influence in this way, however.

Stumpage Rates. It cannot be stated in too strong terms that no such thing as a standard stumpage price is properly possible on any Forest or group of Forests. The result of the standard stumpage prices while in force was that only the very best and most accessible stands were put on the market. A proper policy should withhold these heavily stocked stands from sale for reasons already outlined, by encouraging the sale of the more poorly stocked and decadent stands, by making such stumpage prices on them as would encourage their utilization wherever they are accessible at all. This is the policy which it is endeavored to pursue on the Snoqualmie Forest. Had the policy of fixing standard prices continued, more timber would be taken from the Forest if a proper area were cut now than could be taken 20 years hence by cutting an equal area. The first essential, therefore, to proper management is to get away from the idea of standard prices and make the prices of each sale on its merits.

Furthermore, stumpage rates have not been and are not yet consistent as between different species. For example, the average price on hemlock stumpage so far is $1.25 per M feet. Yet it is entirely evident that with hemlock logs at $6 per M in the Sound, hemlock cannot possibly be utilized except at a loss at a stumpage price of $1.25. The consequence is that while the Government is receiving more than the value of the hemlock, we must reduce fir and cedar prices enough to make this up. This has a serious effect on administration of sales, since it is almost impossible to get loggers to take the hemlock, knowing as they do that it is taken at a loss. It is almost too much to expect that they will take into consideration the fact that what they are paying for the hemlock is really

payment for the fir and cedar. It would be very much better policy to sell each species at its true value, since the returns would be as great, or greater, and the administration of sales much simplified.

Since the Forest Service can not now, and probably never can do its own logging, it is not to be expected that as much can be made from the Forests in this country as is made in others. Loggers wish to make at least from $1 to $2 per M profit, and in order to justify them in assuming the risks they must do so. Yet the function performed by the logger for this sum could be performed by the Government for 50 cents per M. This function consists only in the employment of capital in logging equipment. As $100,000 in logging equipment will take out 100,000 feet or more per day, or 30,000,000 feet or more per annum, and as 10% depreciation and 3% interest on $100,000 amounts to $13,000 per annum, it is clear that the interest and depreciation on capital amounts to only about 43 cents per M. Since wages are paid from the product of labor, no additional capital investment is necessary on that account. The idea that the Government can not manage any work as cheaply commensurate with fair treatment of labor and quality of the work as private individuals is now an exploded one, due to the work of such Government Departments as the Reclamation Service. It is therefore apparent that we can not hope in this country to make as high profits from the National Forests as do those countries where utilization is performed by the Government. This point is mentioned here only as an explanation for lower profits, since it is manifestly impossible for the Government to do the logging itself under present conditions, especially with 25% of the gross receipts going to the State.

Making Sale Contracts. The proposition has been advanced that possibly it would be better to sell by estimate instead of actual scale. This would be a very serious backward step. Probably considering the cost to the purchaser and to the Forest Service together, some expense would be saved, though it would really be very little in this region where scaling and administration of sales run from five to ten cents per M feet. Sale by estimate will require a corps of very expensive cruisers. Even at that there is no possibility that the out-turn of sales would be as great as under the scaling system, for the reason that in purchasing timber by estimate the purchaser must always give himself the benefit of the doubt of the estimate, and buy on a conservative estimate. If he attempts to purchase at the exact estimate he is sure to estimate too high at times, with the consequence of possible bankruptcy. In purchasing on the basis of the actual scale he can calculate his costs and profits very closely, and pay full value for the timber. Another serious objection to sale by esti-

mate is the fact that it introduces the possibility of easy graft, which can hardly be detected. It would be very easy for a purchaser to approach any cruiser who was open to bribery, and make arrangements whereby the estimates of an area would be reduced. Detection is almost impossible in these cases, for the cruiser can always plead an error of judgment.

Although it would be unwise to make large sales by estimate, small sales might properly be so made in most cases.

Administration of Sales. The Forest officer placed in charge of a sale is naturally presumed by the purchaser to represent the Service, and that when he accepts the area his acceptance is final. It should be adopted as a fixed principle that when the Forest Service puts a man in charge of a timber sale it will stand for the mistakes he makes with no attempt to charge them over on the purchaser later.

It is perfectly legitimate when an inspection officer from the District Office, or an officer from the Supervisor's office visits a sale and finds that it has not been administered as it should, that different requirements should be enforced in the future, but it is wholly unfair to attempt to enforce these requirements on past work except in the case of brush piling and similar work in clearing up the area. It is particularly disastrous to the timber purchaser in this region, where steam logging is used, to be required to go back and take material which he left when he had his lines around a part of the logging area. In fact, it is impossible for him to do so, and his only alternative is to pay a double price for the material left. Requirements of this kind may rob him of his entire profits on the sale, or even worse. It is of course entirely legitimate to charge a double price on the material left when the Forest officer on the ground has kept him informed of the fact that he was not utilizing the timber close enough.

In short, the Forest Service should expect to bear the loss caused by any inefficient employés which it may employ from time to time, and not attempt to charge it to an innocent purchaser. If these principles are followed, a great deal of trouble will be avoided. Supervisors should inspect sales on their respective Forests frequently enough to see that the administration of each sale is carried out as it should be, and no one should be employed as Supervisor whose final decision in such matters the Service is not prepared to accept.

Method of Regeneration of Cut-over Areas. Careful observation of existing cut-over areas, together with a logical consideration of the possible methods of regenerating cut-over areas, leads, it seems to me, to the inevitable conclusion that in regenerating very old, heavy, over-mature stands under the climatic and other conditions existing in this region,

artificial regeneration is by far the best method to be used. First, because it is better; second, because it is cheaper.

It is true that there are many wonderful examples of close young stands resulting from natural reproduction in this region. Close observation shows, however, that most of these did not originate after logging at all, but after old burns which left very numerous seed trees, on account of the extreme resistance of Douglas fir to fire. Those which did originate after logging originated in the days when stumpage had no value and therefore numerous trees of the poorer quality were left on every logging area. Modern logging does not leave such trees, except at a considerable financial sacrifice.

Artificial regeneration is better, because by proper methods it will result in more uniform stands, with fewer fail spots. If it is undertaken as soon as the timber is removed and the slash burned, there is not the risk of the area coming up to brush, and getting in condition where neither artificial nor natural regeneration can succeed, that is run where natural regeneration is relied upon. Where natural regeneration is relied upon it will take several years to show its success or failure. By the time failure is evident so much brush will be on most areas as to render artificial regeneration impossible except at a very heavy cost. The loss of a part of the productivity of the area during the period of natural regeneration always results, while if artificial regeneration should finally be necessary on some areas (as without the least doubt it will) the entire loss of the productivity of the area during its period of idleness will result in addition to the heavy cost of artificial regeneration on brush-covered areas.

With natural regeneration only species now on the ground can be secured in the stand to follow. With artificial regeneration any suitable species desired can be introduced and proper mixtures maintained. It goes without saying that it is an incalculable advantage to use several species in forest management in any one region. This secures the greatest possible safety against fire and against insect attacks, while at the same time providing the most useful material. The advantages of mixed stands are well known, including especially their immunity against insect attack, since even if part of the stand is taken, the remaining species may survive to make the final stand.

Among the native species in this region suitable for general use in forest management are Douglas fir, western white pine, Sitka spruce, western red cedar, western hemlock and the true firs for lower slope areas. The first three all give almost equally rapid growth. Spruce should be used in bottom lands and stream valleys, while fir and pine are equally

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suitable for slopes. While these three take precedence for the main part of the stand, the remaining species will be very useful as an understory under pine and Douglas fir stands, since without subtracting from the growth of the pine and fir, a great deal of material can be produced.

This may be the only forest region in which there are National Forests where artificial regeneration is cheapest. I am convinced that this is the case here, however. A few comparisons suffice, I believe, to show this. (1) *Regeneration by means of scattered seed trees.* It takes only a little observation to show that this method is practically impossible, for the reason that scattered seed trees will almost always be thrown by wind within a short time after removal of the surrounding stand. If this were not the case, however, the cost of using seed trees is too heavy. With the large trees which it is necessary to use, if Douglas fir is to be obtained in this region, it is safe to assume that at least three trees per acre would have to be saved. In old mature stands of Douglas fir in which all our cutting will take place for the next 50 years or more, the smallest Douglas fir trees available will contain from 2 to 7 thousand feet each, or 6 to 20 thousand feet per acre. This means an investment at present prices of $15 or more per acre in seed trees, all of which will be lost before cutting can again take place on the area. In addition the loss to the logger will be heavy on account of his failure to fully utilize the roads that he has built. This loss will amount to at least 50 cents per M, or $3 or more per acre. This method is therefore far more expensive than artificial renegeration, even by planting. The cost will be still greater as stumpage advances. Defective trees might sometimes be used without much loss in timber, but as they soon die, they constitute a serious fire risk, since through them sparks may be thrown for great distances in case of fire. (2) *Regeneration by means of groups of seed trees.* This method is also practically impossible except in case of groups on inaccessible areas on account of most of the trees in groups being thrown by wind. The logger will also be subjected to a loss of 50 cents or more for every M feet left for seed trees, due to failure to fully utilize his roads. This will amount to more than in the case of scattered seed trees, probably running up to $10 per acre to the logger, and at least as much in loss of timber to the Forest Service. (3) *Regeneration by means of cutting in strips.* This method is probably impracticable at the present time on mountain slopes, where all National Forest cutting is located, though by cutting wide strips it could be used in flat or rolling country. It will also involve the loss of considerable timber along the edges of the strips, and a loss in road-building to the logger still heavier than in the case of groups. All of these methods also involve considerable cost in protecting trees reserved

for seed, when the slash is burned on the area, as must be done following logging.

It does not seem necessary to consider any other means of natural regeneration if pure or nearly pure stands of Douglas fir are to be the object of management. Poor hemlock stands can in some cases be secured without additional cost in logging, or investment in seed trees by merely leaving the slash without burning; but since the growth in them will be insignificant in comparison with Douglas fir stands, and the material which they yield of little value, I take it they will not be considered for more than limited areas.

In addition to the heavy cost involved in securing natural regeneration, there is always doubt of its being possible in extremely old stands in which cutting is now taking place. In connection with seed collecting in the fall of 1909, careful examination was made of many old stands in which logging was taking place, with the result that although it was a good seed year, practically no cones could be found on the Douglas fir. It seems evident, therefore, that natural regeneration is very doubtful by means of seed trees or groups of seed trees of this class, even if this method is attempted.

Contrasted with the above methods, artificial regeneration can be made sure by planting at a cost of not over $10 per acre, and there is every reason to believe that seed spots at a cost of not over $3 per acre will be successful, wherever there is any possibility that natural regeneration would succeed.

In connection with the consideration of the relative cost of various methods of regeneration, it is worth while to examine into the probable cost of artificial regeneration on a Forest of this size. The area which will be cut over during the next few years will not exceed 2,500 acres in extent, annually. If this were to be regenerated by planting at $10 an acre, the annual cost for the Forest would be $25,000. By seed spots, which are likely to be as successful as natural regeneration, the cost at $3 per acre would be only $7,500. Not very heavy, considering the fact that whenever the cut increases to the extent necessary to involve the regeneration of this amount annually, the income of the Forest from timber sales will amount to at least $200,000 per year at present stumpage prices.

In the above, only the total cost of various methods of regeneration has been considered regardless of on whom the cost will fall. Attention should be called to the fact, however, that it is not at all necessary for the Forest Service to bear all this cost. It can be just as legitimately put on the purchaser as has the cost of brush disposal in the past. As a

matter of fact, in this region, the cost of artificial regeneration will not be as much per M feet as is the cost of brush disposal where piling is required.

Thinnings. Thinnings can undoubtedly be made in 30 to 40 year old, or older stands whenever transportation is available, 10 years hence. The total amount for many years to come will not be large, as would seem to be the case at first thought, because only approximately one one-hundredth of the area will be ready for thinning at 30 years from the present, two one-hundredths at 40 years, three one-hundredths at 50 years, etc., if thinnings begin at the 30th year and occur every 10 years. The product would be small at 30 years. Two thousand feet to the acre on 2,500 to 3,000 acres means only 5,000,000 to 6,000,000 feet for an entire National Forest. When the second thinning of about 3,000 feet to an acre comes in at 40 years we will have a product from thinnings proceeding simultaneously in 30 and 40 year old stands of 12,500,000 to 15,000,000 per annum on one Forest. When the entire Forest has been cut over, the product from thinnings will be enormous; probably 100,000,000 per annum. That thinnings will be possible where transportation is available is not open to doubt. As a matter of fact they are already salable in 50 to 60 year old stands, for pulpwood and hewed railroad ties, where transportation is available.

Need of Detailed Plans. A good many persons have assumed that as cutting is now in no case of a Forest in this District up to what the Forest will bear, or probably even up to what a watershed will bear, detailed plans are wholly unnecessary, and hence any steps toward preparing them. I believe this attitude to be very ill-chosen, because there are some Forests, at least, where cutting will be brought up to the cutting limit within from 2 to 5 years. It takes a good while to collect the data to make a detailed plan, and it is none too soon to start vigorously on this work. If we wait until the need is upon us for the plans, the plans can not possibly be prepared in time. It will probably take 15 years to prepare detailed plans for all the Forests in the District, even if a start is made at once, and as much funds devoted to the work as can be spared from routine work. It is safe to say that by the time plans can be prepared, all of the Forests in the District will be brought to their cutting limits, and it will not be surprising if over-cutting results on some before plans can be prepared.

Working plans are absolutely necessary guides to economic management. Without the collection and use of the data they contain, dead, decadent and other timber needing removal will in many cases be overlooked unless an expensive system of frequent superficial examination of

the forest area is adopted, and even then much will be missed. In other words, not only are they necessary to protect the future of the Forest, but they are even more essential to present economical management. Without them the cost of administration will be too high, and the returns too small. Stands of timber which ought to be left will be cut, and stands which ought to be cut now, left standing.

There is no reason to believe that the appropriations for forest work will be higher in the near future than now, relative to the routine work to be done. The question of whether National Forests shall be under working plans, then, sifts down to whether the necessary routine work shall be done with such efficiency as to make possible the setting aside of some small proportion of the appropriations for this work; whether the funds available shall be spent in office work, or actual work in the field; whether they shall all be spent on work of significance only to this year, or next, or on that from which the results will last for many years. Since no other enlightened country pursues any policy except that of guiding their forest work by more or less careful plans, Americans should certainly not stand alone in doing so.

On the other hand, if the principle of regulating only watersheds is adopted, the idea that we need immediately plans for all Forests can be at once abandoned. Even a superficial canvass of the situation shows at once that not only is there no danger of overcutting on many watersheds at present, but that the chief need is to encourage cutting. It seems obvious that on watersheds where no cutting can be done for several years, present preparation of plans is not only unnecessary, but sheer waste, since by the time cutting can take place the plans will not be as applicable as plans prepared just before the need for them arrives. Nevertheless, development is now so rapid that the resources of the Service will be taxed to the utmost to prepare plans where they are needed, as rapidly as the need arrives. If this work is continued efficiently, as it has been begun, and vigorously followed up, there is reason to hope that national management can be introduced on all the Forests, but only on these conditions. If there is any decrease in the pitifully small sums heretofore devoted to this purpose, we shall have to face unregulated cutting, or no development at all, with the result that in either case the Forests will fail to produce their full product.

STRIP THINNINGS

THEODORE S. WOOLSEY, JR.

(Contributed)

The profession is familiar with the second-growth spruce stands that have come up naturally on abandoned farms in New England. Some of them are so open that the trees are limby and almost unmerchantable even for pulpwood; others have suffered from crowding, and even when 50 years old there are often over 800 trees per acre. This crowding has resulted in short, narrow crowns, and on account of the struggle for root growing space, has undoubtedly diminished increase in diameter and very probably height growth as well. As an illustration of the rate of growth of old-field spruce, the following table is given; the figures are from measurements taken by the writer in 1903, near Pike, N. H.:

TABLE I.—*Rate of Growth of 8-inch "Old-Field" Spruce*

Period.	Increase in diameter.	Increase in height.
	Inches.	*Feet.*
Last 10 years	0.43	10
From 20 to 10 years ago	.67	11
" 30 " 20 " "	.92	11
" 40 " 30 " "	.76	12

How to cut these stands is often a problem. Perhaps the best method would be to cut clear and plant, or, in favorable locations, to secure natural reproduction by clear cutting in strips of the proper width. But probably the composition of the resulting stand would be unsatisfactory. For scenic reasons, it may occasionally be desirable to merely thin these spruce stands in order to secure a better composition, advance reproduction, and to realize an immediate profit from a partial sale of the stand; in other words, to adopt a very conservative method of management and yet profit financially.

Where thinnings alone are desirable there can be no doubt that the best silvical treatment of the stand would be secured by thinning out carefully selected trees. There is a practical objection, however. These thinnings must yield a profit. Men who have tried cutting single trees in a dense stand of second-growth spruce know that it is impracticable under present market conditions. To do this effectively it would be

necessary to pull down, by some means, almost every tree felled, since the stand is so crowded and the dead limbs so persistent that the trees do not fall of themselves when cut. Under these conditions no jobber would undertake thinning out single trees at a reasonable price. Occasionally, therefore, where clear cutting is not practicable, some method of cutting must be devised that is possible under present conditions. The system proposed is as follows:

Cut narrow, alternate strips through the stand, radiating in parallel lines from the main hauling road. The width of the strips should vary according to the density of the stand, averaging from one to two trees in width, or about 5 to 10 feet. Between the lumbered strips should be left lines of standing trees of approximately the same width. The trees nearest the main hauling road should be felled first, and into the opening each succeeding tree should be felled until the cleared line is completed. As each tree is felled it should be limbed and sawed into pulpwood lengths, the tops lopped, and all branches piled and burned in the openings, or if this is impossible it could be piled under the line of live trees which are to be left. The uncut strips should also be thinned lightly; the trees removed can be thrown into the cleared lines.

The practicability of the system was tried out by the writer in 1903. The idea was so simple that the chopper had no trouble in making the thinning independently after the first line was marked as a sample. One man thinned 1.1 acres in four days, yielding 13 stacked cords of pulpwood. The cost of cutting proved to be less than five per cent greater than the cost of clear cutting. The sample cutting was made in a growth of "old-field" spruce, 52 years old, growing on loamy gravel of moderate fertility. The stand was practically pure, with a small percentage of balsam and only a scattering of birches, beech, and maple. In this stand the spreading crowns of the hardwoods often suppressed the neighboring spruce; consequently, so far as possible, all "wolf" hardwoods were removed. The total stand was estimated at 34.2 stacked cords per acre, cutting to a top diameter limit of 4 inches; this netted about $2 per cord. Of this stand 38 per cent volume was removed and 62 per cent left standing. So heavy a thinning must be termed a partial clearance, and is probably too heavy for the best results. Probably better results would have been secured if only 20 to 25 per cent of the stand had been cut. The percentage removed can be regulated by varying the width of the strips left uncut. The following table gives in detail the results of the cutting:

TABLE II.—*Number of Trees Cut and Left Standing on 1.1 Acres*

Diameter, breast-high. *Inches.*	Spruce. *Left.*	Spruce. *Cut.*	Balsam. *Left.*	Balsam. *Cut.*	Hardwoods. *Left.*	Hardwoods. *Cut.*
3	2	..	..	..	2	..
4	77	20	3	..	5	..
5	150	44	6	1	16	2
6	115	55	1	2	11	6
7	113	45	..	4	6	6
8	60	27	4	1	4	4
9	30	29	1	7	5	3
10	25	12	..	5	2	1
11	5	2	..	5	1	2
12	2	1	..	..	..	2
13	...	..	..	..	1	2
Total	579	235	15	25	53	28
Under 7″	457	164	10	7	40	14
7″ and over	122	71	5	18	13	14

From the foregoing table it is apparent that a considerable percentage of balsam was removed, since this was felt to be an undesirable species. The smaller hardwoods and a few of the larger stems could not be removed because of the difficulty of felling without undue damage. As a result of this method of thinning it is likely that with more growing space the crowns of an intolerant species, such as red spruce, will increase in vigor and consequently after 10 or 15 years increased growth, to a small extent, should be expected. Ordinarily the thinning should be made when the stand is 25 to 30 years old. No appreciable increased growth has resulted in the stand shown in Table II, probably because the thinning was delayed until the trees averaged 52 years. The composition of the stand can be improved by removing the undesirable balsam and hardwoods. Perhaps in some instances poorly developed hardwoods might be girdled. It is likely that advance reproduction of red spruce, the desirable species, will take place in the openings where sufficient light has been admitted, whereas, under the uncut strips insufficient light will be admitted to allow the balsam to get enough of a start to crowd out the spruce in the primary struggle for occupation of the ground. Insufficient light is admitted in a dense stand, even in the open strips, to allow the hardwood to crowd in. The capital invested in the stand will be materially decreased, while at the same time it is likely that the total volume of the final harvest in 20 or 30 years would be about the same, or, in rare instances, more softwood than if no cutting was made, because of the removal of hardwoods from competition. Mr. R. C. Hawley, Assistant

Professor of Forestry at Yale, inspected the cutting in 1908. His critical comment on the cutting is interesting:

> "The spruce seems to have come in on the spots where the needle cover was broken and the balsam on the spots where the cover was not broken. To the eye there appears to be more spruce in the alleyways than under the uncut timber. It seems to me that this style of thinning is of use in dense stands of spruce mainly to secure reproduction before the cutting and then allow the clear cutting, but as a method of thinning to get increased growth, I do not believe it worth carrying on."

The writer does not propose this system of thinning for general use, but must confess that it is merely a method that might be adopted rarely—perhaps in one case out of a hundred—under the exact conditions described. So far as the writer is informed, this method of strip thinning has not been tried out in Germany, since the main factor—costly execution of regular thinnings—is lacking as an incentive; yet abroad the density of natural reproduction is sometimes reduced by strip clearings.

HARDY CATALPA

A Study of Conditions in Kansas Plantations

A. E. OMAN

(*Contributed*)

The writer had occasion, in the fall of 1908, to study conditions in the four well known catalpa plantations in Kansas described in Forest Service Bulletin No. 37. It was essentially a study of sprout stands, since the original stands had been harvested one to seven years previous to this time. While there is a difference of opinion among foresters as to the merits and profitableness of this species for commercial planting, hardy catalpa has many qualities which will keep it in the lead for fence posts and pole production in the middle western states. This paper will merely attempt to set forth a number of facts and conditions observed during this field study. There is still a wide field for investigating the best methods of handling plantations, especially in regard to securing successive and profitable second growth stands.

Reproduction. Natural reproduction of catalpa was observed in the Yaggy plantation, where it has occurred to a very limited extent. The seedlings were short and spindling, for their age, and will succumb to the shade of the larger trees in the stand. Natural seedlings grow at a disadvantage in prairie plantations. They lack the vigor of cultivated planted stands. Weeds and desiccating winds rob them of needed soil moisture, a generous supply of which is so essential to forest trees on prairie sites. This method of reproduction can not, therefore, be considered in regenerating stands in artificial plantations.

Catalpa will grow from cuttings provided the soil moisture conditions are favorable. A fair degree of success could probably be attained on sandy loam sites where there is good sub-irrigation, but where the permanent water-table is not too close to the surface of the ground. The lack of moisture at a critical period during the first season would very probably prove fatal to cuttings. This method is not recommended as a means of propagating the species on a commercial scale.

Catalpa posts will frequently send out shoots if set while still green. A striking example of such growth is shown by two trees on the Yaggy plantation which have developed from posts set in the ordinary way. The posts, it seems, took root strongly and at the same time sent out

shoots from the top ends. Eventually the top ends healed over, and the posts have grown into trees over eight inches in diameter and more than twenty feet high. Thriving shoots were observed growing from three-foot fence stakes used extensively in fencing on the Munger plantation. The shoots seemed to thrive irrespective of whether the small or butt ends of the stakes had been driven into the ground.

No evidence was found to support the contention held by some persons that catalpa roots will send out suckers when bruised. Single furrows plowed between rows of trees to control ground fires when burning brush, and the plowing of fire guards on two of the plantations have not given rise to any shoots from mutilated roots. This species is, therefore, free from the ill repute earned by black locust and ailanthus, which tend to sucker badly.

The observations just cited are given merely as interesting and verified facts relating to the behavior of the species. Artificial stands must be started from plants raised from seed, in nurseries. Second-growth stands will develop from stump sprouts. Crops from original seedling stands have proved successful and profitable in Kansas. The chief concern is to make successive sprout crops equally or more so.

The Effect of Cutting Back Young Sprouts. It has become an almost universal practice to cut back seedling stands of catalpa one or two years after planting. While no conclusive evidence could be obtained in favor of or against this practice, general observations indicate that it is advisable. The advantage gained is the impetus to height growth which results in straighter boles. A sprout which grows from 8 to 10 feet the first season is very likely to grow at least 3 or 4 feet the following year. The same tree, if not cut back, would probably not more than equal that height in three years' growth and would have an additional whorl of branches and chance to fork.

Where the quality of the site insures a height growth of 12 to 15 feet in three years the trees go more to bole than to much-branched crowns. And it is just this period in the life of young stands that the quality growth of the individual trees is determined, for if the trees reach the heights mentioned, even if planted 6 feet by 6 feet or 5 feet by 8 feet apart, the crown development will be ample to at least partly diffuse the light and thus check the growth of the lower branches. Small dead twigs are quickly shed, but branches which grow to one inch or more in diameter before becoming suppressed, are almost certain to persist through the relatively short rotation of a prairie plantation. Self-pruning, therefore, takes place in direct proportion to the rate of height growth, the spacing being the same.

Keeping Down Stump Sprouts. Catalpa stumps sprout vigorously, and whether they are from two year old seedlings or from old trees it becomes necessary, eventually, to remove all but one or two sprouts on each stump. Cutting back stump sprouts during the summer season disposes of them effectually. On the large plantations, however, it has not been found convenient to cut back sprouts in that season because men are scarce and wages high, and less work can be accomplished in hot weather. When the work is done during the winter months it generally becomes necessary to repeat the operation two or three times.

Where tried it was found advantageous to defer cutting back the surplus sprouts for two or three years. Many of the shoots will be more or less recumbent and the result is effective shading of the ground. This lessens evaporation of soil moisture, aids in excluding herbaceous vegetation, and checks the rapid scattering of accumulated leaf mould and litter by the wind. The presence of several shoots on a stump for two or three years does not materially affect the growth of the dominant ones. Each sprout draws its nourishment from its particular portion of the stump and so does not rob the others, and in such a short period the struggle for dominance is not detrimental to those which are to be permanent. The extra sprouts must be removed, eventually, however, to prevent overcrowding and to lessen the drain on soil moisture. Two or more sprouts may be left on a stump wherever there are openings in a stand.

Spacing. On the Yaggy plantation, height and diameter growth in second growth stands has not been noticeably greater where the stand has been thinned to about fifty per cent of the original planting, or approximately 950 trees per acre, than in unthinned stands on correspondingly good soil, and at the same time trees in the thinned stand have more branchy crowns. A portion of the Hunnewell plantation, which produced the greatest yield in posts and poles, has the poorest prospect for a second crop. This unfavorable condition is due in part to summer cutting and the early disposal of all brush by burning, but probably to a greater extent to the tall growth and early development of the original stand, and the resultant stagnation of growth because of overcrowding. On a portion of this plantation many trees were dying or had died when the final cutting began, and the sprout stands are consequently open and lack vigor. Wider spacing or cutting on a shorter rotation would have prevented this adverse condition.

A reasonable degree of crowding is essential to insure desirable growth of catalpa, and the spacing should be determined by the quality of the locality. Thus, on the best bottom and in Greenwood County (Brookover plantation), where five-year-old trees had attained 20 to 26 feet in height,

about one-third of the trees were already seriously suppressed and only 12 to 16 feet high. On sites where such height growth is insured, a spacing of 5 feet by 8 feet or even 8 feet by 8 feet would afford better chance for even development of the stand, and still the strong tendency toward height growth would insure a good quality growth. But such wide spacing could not be recommended for prairie sites, as for instance on the Munger plantation in the same county. On the high prairies the trees grow less rapidly and with wide spacing a relatively long period is required to establish a crown cover, and meanwhile the stand will not make the best quality growth for the site.

From the standpoint of soil moisture and soil fertility alone, wide spacing should be used in the semi-arid regions and on thin or sandy soils. Economy and utility, however, demand as close planting as the quality of the site will warrant. Giving the several factors their due weight, the spacing recommended for Kansas conditions would be from 4 feet by 6 feet to 6 feet by 6 feet on prairie sites and thin sandy soils, and from 5 feet by 8 feet to 8 feet by 8 feet on good creek or river bottomland.

Pruning. "We will be glad to do the pruning provided the trees will make satisfactory growth," declared the proprietor of one of the plantations when it was argued that his plantation, thinned to 7 or 8 feet by 6 feet, would grow mostly to branches. It is not probable, however, that any extensive pruning will prove practicable or profitable. When the quality of the site is not conducive to rapid height growth, the production of first-class post and pole material can not be greatly augmented by pruning, without prohibitive cost.

It is not advisable to prune heavily in two or three-year-old growth where the branches occur in congested whorls. Where this had been done in two-year-old sprouts, in a Shawnee County plantation, the leading shoots, bearing luxuriant foliage, were badly broken by wind. Another objection to early pruning is the exposure of the pith, which seems to break down readily in one and two year old branches, opening possible avenues for infection by fungi. The practice of nurserymen, of going through their nurseries early in the spring and rubbing off the extra buds on the stems of growing stock, while the buds are still tender, could no doubt be extended to catalpa plantations with good advantage, and if judiciously practiced this method might obviate the necessity of cutting back newly established plantations.

Shelterbelts

The four old plantations under consideration were completely cut over during the years 1902 to 1906, inclusive. Only on the Yaggy plantation was the plan of leaving shelterbelts tried in a systematic way. However, most of the alternate strips, or belts, left for this purpose were removed after being left only one year.

When sprouts are thinned to one to each stump, after one year's growth, the remaining ones are in danger of being broken, or permanently bent, as a result of windstorms or high wind with rain. To offset this loss the extra sprouts may be left uncut until the third winter, as this will serve the double purpose of preventing loss by bending and serious injury from girdling by rabbits. Although shelterbelts would at least in part check loss from bending and breaking, the disposition of plantation owners seems to be to dispense with them altogether and to take chances from losses of this kind.

If a comprehensive system of interior shelterbelts is to be used, the belts should be permanent. Preferably a more densely branching species should be used, as, for instance, Russian mulberry. These belts should consist of two or three rows of trees at intervals of not more than twenty rods.

Rows or belts of taller species around plantations are no doubt beneficial along exposed borders. Frequently, however, much of the apparent benefit is more the effect on evaporation of soil moisture than the checking of winds. Two plantations belonging to T. F. Leidigh, Hutchinson, Kansas, illustrate a contrast in this respect. One plantation, on heavy, second-bottom soil, has a row of Russian mulberry trees along the south side. Where there is a break in the shelter row the catalpa trees are shorter, apparently because of the exposure. On the other hand, on a tree claim in the sand hills, a few miles farther north, the trees in an exposed southeast corner of that plantation do not show any harmful effects from full exposure to south winds. The situation in this case is the border of a shallow basin, so characteristic of the sand hills, in which the soil moisture conditions are very favorable.

Undergrowth. Shade-enduring, woody undergrowth will never play an important part in the success of artificial plantations in the prairie region. Catalpa must be planted sufficiently close to secure the best quality of growth as well as the greatest possible yields. Clean cutting will be the method of management most generally used. Thus, a stand must be harvested on a relatively short rotation and before undergrowth can prove of any benefit. In the process of cutting, also, woody under-

growth would be largely destroyed, or it would suffer later from excessive light and desiccation by wind, and thus fail to afford any considerable protection during the formative period of the sprout stands.

There is very little evidence of woody undergrowth in the three to six-year-old sprout stands on the old plantations. The Farlington and Hunnewell forests probably have more than any of the others. But where most abundant it consists of an inconspicuous growth of snakeroot, sumac, briar, grape and ivy vines, and scattered seedlings of hackberry, pin oak, sycamore, mulberry, and dogwood.

Annual and permanent grasses are a menace to cut-over stands, since they deprive the trees of soil moisture. On none of the plantations, however, have permanent grasses gained any alarming foothold. On the Hunnewell and Yaggy plantations, wherever the brush was burned or removed immediately after the removal cutting, crab and tickle grasses, sandburs, and similar vegetation are abundant. The struggle to overcome this condition will hold the sprout stands back to some extent.

Burning the brush deprives the surface soil of needed protection, which the brush and leaf mould would afford, and also of humus and soil fertility. The tops and branches could no doubt be lopped for less than the cost of burning the brush, and the litter would be very beneficial as a protective soil cover.

Soil and Site Requirements. Catalpa requires a deep, fertile, porous soil for good growth. It will not succeed on heavy, poorly-drained land. It grows well on prairie soils provided there is at least 20 to 30 inches of good friable soil before heavy clay is encountered. It is not adapted to poor sandy or stiff clay soils, or those which have a tenacious gumbo subsoil at a depth of less than two feet. Even where permanent water is within five to seven feet of the surface, a poor sandy soil will not produce satisfactory growth. A sub-stratum of clay or gumbo, underneath several feet of good soil, especially if the soil is a light sandy loam, is of advantage, since it tends to hold back the seepage water and prevents leaching of plant food from the surface soil. Catalpa will not withstand much alkali in the soil. It is much more sensitive than black locust in this respect.

Hardy catalpa will endure considerable flooding, and even submersion. The June, 1908, flood caused overflow and standing water on the Adams plantation in Shawnee County, Kansas, for practically one month. Fifty acres of one-year-old seedlings, planted the same season, were totally submerged for an entire week without being killed.

The following descriptions illustrate the character of the soil on a variety of situations on which catalpa has made good growth in the various localities studied:

Hunnewell plantation: A rich marl, dark in color, with a fair quantity of humus. The surface soil, having a depth of 25 to 30 inches, is underlain by a stratum of gumbo.

Yaggy plantation: Black sandy loam 14 inches deep, then 6 inches of yellow clayey sand which merges into a layer of sandy clay 8 inches deep. At about 30 inches down is a stratum of tough gumbo 10 inches, more or less, in thickness. There is pure sand below the gumbo, and water at a depth of 5.5 feet. The roots do not penetrate the gumbo to any appreciable extent.

Munger plantation: Rich, black, prairie loam 16 to 20 inches deep; granular clay 8 to 15 inches deep; and below that a tenacious yellow clay.

Brookover plantation, Greenwood County: A surface deposit of silt, and strong, black, creek-bottom loam 2 to 3 feet deep; under this, 3 feet of brownish loam, crumbly, with a trace of limestone granules at a depth of 8 feet; total depth of good soil about 10 to 12 feet. Humus abundant.

Adams plantation, Shawnee County: Light sandy loam, 12 to 18 inches deep; then 6 feet or more of black sandy and silty loam. River sand at a much greater depth.

Returns—Yields—Utility. The returns obtained from the old plantations in Kansas checked up pretty well with the estimates given in Bulletin No. 37. Thus, the average of the estimates of twelve sample acres in the Hunnewell plantation, made in 1901, was approximately $400 per acre. The average return obtained in 1905-1906, when the removal cutting was made and the products marketed, was approximately $500 per acre. There was, however, a wider difference in the actual returns from respective units of the plantation than was indicated in the estimates in the Bulletin. One particular 40-acre unit on which was obtained a large proportion of 14 and 21-foot telephone poles yielded the highest average for this as well as the other plantations, namely, $680.00 per acre. The Bulletin estimate for an acre on the same forty was $394.40. Its maximum estimate for this plantation with which a comparison of the actual returns could be made was $511.00. The actual return from this forty was $580.00 per acre. There was approximately a corresponding difference in the actual returns and the Bulletin estimates for the other plantations.

The yields in posts and poles on the several plantations indicate that on good average situations, with the trees planted 4 feet by 4 feet or 3½ feet by 6 feet apart, the crop, harvested in 20 to 25 years, should yield about 3,300 posts per acre. On poorer sites the yield grows corespond-

ingly less at a rapid rate. But, as already intimated, such a rotation period is much too long for close planting. A rotation of 18 or 20 years does very well for post production. Good sites will produce a large proportion of poles from 14 to 30 feet long in that time. Telephone poles will yield twice the returns obtained from the same material cut into post lengths.

It is a notable fact that the four old catalpa plantations in Kansas were cut over and the products marketed in the short period of four years. The consensus of opinion is that an advance of 50% over the former prices could be obtained for similar material at this time. Ranchmen in western Kansas and in the Panhandle of Texas are particularly eager for catalpa posts. A certain buyer, when asked why he could not use some split walnut posts that were offered to him, said: "I haul these posts from 75 to 80 miles. I can load 200 of these little posts and haul them with my team, while of the others I can load only 75 and have to take two teams to haul them." Ranchmen cannot hope to build fences to hold stampeding cattle. Posts two to three and one-half inches in diameter answer their purpose.

Compared with the other fence-post trees, osage orange, Russian mulberry, black locust, etc., the catalpa is most easily harvested and marketed because of its light weight and the ease with which it is handled. Its light weight is a great factor in shipping by freight as well as in hauling on the ranch.

Catalpa poles are in strong demand for rural telephone lines, and this demand will grow at a rapid rate. There are no records of catalpa having been cut for telegraph poles. Particularly good sites as well as technical care of plantations would be necessary in order to obtain even a fair proportion of poles which would fulfill the rigid requirements of the trade. The Frisco Railroad Company ordered several hundred ties cut on the Farlington plantation, but the work was quickly discontinued, since this was not considered the most profitable use of the product. Eventually the few ties that had been cut were split into posts. No data were obtained to show the actual use of catalpa ties by the railroad company. Incidentally, a considerable number of split posts were made on the Farlington plantation. The difference in prices for small and large round posts made the smaller grades more profitable. The following table will illustrate:

Grade of post.	Diameter of post.	Value (each).
No. III.........	2 to 2½ inches.	3 cents.
No. II.........	2½ to 3 "	6½ cents.
No. I.........	3 to 4 "	8½ "
Standard.......	4 to 5 "	10¢ (equivalent to two No. I.)
8 foot post.....	4 to 7 "	20¢ (equivalent to six No. II.)

The making of split posts was not equally successful on some of the other plantations. If split posts could be made without too great waste it would be less urgent to crowd the stands by close planting.

The Kansas plantations have not as yet been cut over a second time. There is every reason to believe, however, that second-growth wood will be equally as durable for posts as the original growth. In the numerous three to seven-year-old sprouts, cut down for the study of growth, the sapwood was invariably that of the last two seasons' growth, or two rings only. The question of an equal or better quantity and quality production of wood in the second-growth stands, as compared with the seedling stands, is, however, very uncertain. This is due, at least on two of the plantations, to the fact that the harvesting of the original stand was in each case deferred too long considering the close planting and the greater average height growth of the trees on those plantations. The conditions on the Leidigh tree-claim, already mentioned, emphasize the relation between spacing, site, and height growth. The site is undulating sand-hills, fully exposed to south and south-west winds. The soil is very light loam. There is a particularly impervious stratum of clay at a depth of five or more feet. The moisture condition approaches that of sub-irrigation. The trees planted there about the year 1886 and left without further treatment until some recent cuttings were made, seem to have reached their maximum development several years ago and are showing signs of decay. The trees range only from 16 to 25 feet in height, according to whether they are on the dry ridges or in the more moist and fertile soil in the natural depressions. The corresponding diameters range from 2.5 to 6 inches, at breastheight. Although the trees are spaced 4 feet by 4 feet apart, only a few are suppressed and evidently none have died. Sprouts from stumps of trees removed at different intervals, by selection cutting, show a remarkable growth for the situation. A short table of measurements taken will best illustrate this:

Age. *Years.*	D. B. H. *Inches.*	Number of trees measured.	Height of trees. *Feet.*
4	1.5–2.5	16	12–16
6	2.0–3.0	7	14–18
8	4.0–5.0	4	20–25
1	... ...	..	3–11

Even the four-year-old sprouts had attained the height of the surrounding trees, the dimensions in the table reflecting the height of the adjacent trees where the sprouts occurred. Evidently the relatively low growth of the stand admits of sufficient light to force rapid growth in the

sprouts. The same relation should be obtainable on stronger soils by determining the proper ratio between spacing and height growth. In this little plantation, then, with selection cutting, second growth has excelled the original growth. The sprouts show a remarkably vigorous growth which even exceeds that obtained on any of the large old plantations in the state.

Suggestions for Planting, and for Treatment of Plantations. The planting site should be plowed in the fall or early spring and should be further prepared by harrowing with a tooth or disc harrow just before planting. When new land is to be planted, field crops should be grown for two or more years so as to remove all permanent grasses. It is usually advisable to plant in the spring and to use 12 to 24 inch, one-year seedlings.

It is of utmost importance to secure a strong, true-to-name strain of planting stock. One-year-old seedlings may cost $2.00 to $5.00 per thousand. Prices above the given maximum are exorbitant. Where extensive planting is contemplated it is most economical to establish a small nursery and raise the seedlings on the plantation.

The proper spacing of trees should be determined for each plantation by a study of regional and site conditions. A spacing of 4 feet by 4 feet is advisable only when early thinnings can surely be made, or where the site will not produce a stand more than 18 to 25 feet in height.

Plantations should be cultivated for two or three seasons. Where the rows are spaced 8 feet apart one or both ways, single rows of some short species of corn, of potatoes, or of field peas, may be planted to partly utilize the ground for one or two seasons.

It is usually advisable to cut the young stands back to the ground after one or two season's growth. Numerous sprouts will start from each stump the following season, of which all but two or three of the most vigorous ones should be removed while still tender. This work, if carefully done at just the right time, should be accomplished more cheaply and with better results than cutting back larger sprouts the following winter. This practice, in common use in commercial nurseries, could well be continued by going over the plantation and rubbing off the surplus buds on the one-year-old sprouts, when growth commences the succeeding spring. In fact, this method of pruning suggests itself as a possible substitute for cutting back young stands. The formation of congested whorls of branches, at the beginning of the first few years' growth, could thus be prevented and the usual difficulty of pruning low-crowned trees obviated. Where more than one sprout is left on a stump the extra ones should be removed after there is no danger of the permanent ones becoming destroyed.

Catalpa has been planted in pure stands on all the plantations examined. Judging from the behavior of osage orange, in hedge rows and in pure stands on the Farlington plantation, the advantage of using this species as an associate with catalpa, as has been frequently advocated, seems doubtful. Osage orange is decidedly more intolerant than catalpa as regards both crown and soil space, and in habits of growth the two species are so different that it is improbable that a mixture would be beneficial to either.

FORESTS AND STREAMFLOW

An Experimental Study

CARLOS G. BATES

Presented Before the Society November 17, 1910

The Forest Service and the Weather Bureau have finally combined efforts to investigate the much agitated question of the streamflow relations of forests. The new experiment, which is to be conducted on two typical, small Rocky Mountain watersheds in a region with important irrigation interests, promises to furnish a good deal of the information on this subject which has so long been missing from our store of knowledge. The methods employed are believed to be thorough and the results therefore should be convincing.

The object of the streamflow study as it has been inaugurated on the Rio Grande National Forest is to determine the effect of forest cover upon the high and low water stages of mountain streams; the total run-off from mountain watersheds, as compared with the annual precipitations; and the erosion of the surface of these watersheds. The experience gained in earlier experiments is to be used, and the most accurate measurements possible under the circumstances will be employed. The measurements of the factors concerned will be so made as to furnish in a general way an estimate of the relative amounts of run-off and of evaporated water for each watershed. Since there is a very small possibility of an escape of the water of precipitation by percolation other than through the main channels of the streams involved, there is no third element to be measured. This fact has been established by geological examination which shows that the watersheds are underlaid by a practically impervious mass of lava in which both horizontal and vertical fissures are uncommon.

In this study the comparison of the forested and non-forrested mountain watersheds is to be obtained by means which can not fail to give convincing results. The element of time is sacrificed to this end. Measurements of the streams in two watersheds, both covered with moderately heavy forests, will be conducted for a number of years. In the meantime, all of the factors which may affect the character of the flow of either stream will be carefully measured. By this process a certain relation will be established between the two streams for various climatic conditions of

a known character. For instance, it will be found that a given amount of precipitation produces in one watershed a flood of a given height, and in the other watershed a flood of slightly different height, both, however, influenced by forest covers of practically the same character. Or, again, a given amount of snow melting under given temperature conditions of air and soil produces a certain flow in each stream. When this comparison has been carried on long enough to establish a number of distinct relations between the streams of the two watersheds, one watershed will be denuded while efforts will be made to improve the forest conditions upon the other. There will be, therefore, upon the forested watershed practically the same conditions affecting the flow of the stream in that watershed as during the earlier part of the experiment, while upon the denuded watershed the conditions will have been changed only so far as the forest cover is concerned. Any changes in the relative behavior of the two streams, as before and after the denudation, must, therefore, be accredited to the change in forest cover conditions.

To cite a hypothetical case: Under the original conditions of equal forest cover, a rainfall of 1 inch in one hour produces a flood in Watershed A of 1 foot of water over the weir, the crest of the flood occurring two hours after the beginning of the precipitation, as shown by the automatic records of rainfall and streamflow. In Watershed B the same precipitation produces a flood of 15 inches over the weir, occurring one and three-quarters hours after the beginning of the storm. The two streams, during the progress of this flood, deposit equal amounts of silt in the settling basins as measured by actual weight, and samples of the water passing out of the basins show that the two streams carry equal amounts of finer detritus.

After the denudation of Watershed B a similar storm produces in Watershed A a similar flood as regards volume and time, while in Watershed B it produces a flood of 20 inches over the weir, occurring one and one-half hours after the beginning of precipitation. It is also found that Stream B deposits a much larger amount of silt in the settling basin than does Stream A.

It must be admitted that such comparative records as these, involving one watershed which is left undisturbed, and another on which forest conditions are radically changed, whether or not they prove the contention as to the value of forest cover in retarding run-off and preventing erosion of the slopes of watersheds, must carry conviction which can not fail to assist us to a proper understanding of the value of mountain forests.

The active construction of the dams, roads, trails, and buildings for the streamflow experiment was begun about June 1, 1910, by the Forest

Service in cooperation with the Weather Bureau. The work is now practically finished and the experiment is under way. While no records of importance have as yet been obtained, the methods of procedure in the experiment are fairly clear. I wish to give you briefly a view of the local conditions affecting the experiment and point out some of the important details of the work which will illustrate its comprehensive character.

The Watersheds

The two watersheds at the Wagon Wheel Gap Experiment Station are very much alike with respect to topography, soil, and vegetation cover. A good deal of difficulty was encountered in finding two such similar areas at an altitude which represents a mean between the heavily-watered mountain tops and the low-lying areas where the streams are not permanent. The area of Watershed A is 223 acres and of Watershed B, 212 acres. The former has a total length of 7,100 feet and a maximum width of 1,800 feet. The latter has a length of 4,600 feet and a maximum width of 2,500 feet. It may thus be seen that Watershed A is longer and narrower than Watershed B. The visible lengths of the two streams are 3,400 and 2,300 feet, respectively. Both streams have an easterly bearing, flowing out of the mountains on to the broad bottom of the Rio Grande, where, excepting at the highest stage, they disappear in the loose soil of the river bottom.

The altitude of Watershed A is from 9,375 to 11,360 feet, while Watershed B lies between the elevations 9,240 and 10,940 feet. At these elevations precipitation is sufficient to feed permanent streams. I think it is safe to say that the streams in question have never gone dry, since the season of 1910 represents an almost unprecedented drought in this locality and the streams at the end of the summer showed discharges of .075 cubic feet per second and .050 cubic feet per second, respectively, or about 20 per cent of the annual mean discharge.

In each case the forest cover consists of Douglas fir in the lower reaches and Engelmann spruce at the higher altitudes. Douglas fir on north slopes is representative of the Rocky Mountain form of this tree. On south slopes it forms an open stand of fairly thrifty and commercially valuable trees, the litter in most cases covering the ground only in the immediate vicinity of the trees. On north slopes the Douglas fir becomes more and more supplemented by Engelmann spruce as one proceeds upward. At the heads of the watersheds the Engelmann spruce stands have been considerably damaged by fire, followed by the replacement in some cases of Engelmann spruce, but more generally by stands of aspen in which the forest floor conditions are quite good.

Douglas fir and Engelmann spruce undamaged by fire occupy about 40 per cent of the area of each watershed. In Watershed A the remainder is made up of aspen, under most of which there is good reproduction of coniferous species, and a small area of bristlecone pine. The balance in Watershed B is made up almost wholly of aspen in which there is a smaller proportion of good reproduction.

Both watersheds have been partially burned, the most recent burns being about 17 years old, the earliest as much as 50 years. The only burn not restocking is at the head of Watershed A and represents about 2 per cent of the area of that watershed.

Steps have already been taken to obtain a stand of Engelmann spruce on part of this area, by seed-spot sowing, and similar work has been done in the more open areas of Douglas fir on Watershed A. While the effect of this planting, within the period of the experiment, can be but slight, yet any improvement of the forest cover of Watershed A occurring simultaneously with the deforestation of Watershed B must accentuate the desired contrast.

As a whole, the forest-cover conditions on both watersheds are fairly representative of conditions throughout the Rocky Mountain region which furnishes water for irrigation. The areas most subject to erosion are the steep, south slopes where the gradient is frequently as much as 35 degrees and where the trees are far apart.

At several points on the watersheds there are small areas of "slide rock," and other areas where a soil has only recently been created. Outcrops of rock in place are few in number and represent an extremely small area. Throughout, the fine black loamy soil is interspersed with small stones, yet the depth of soil in most cases is considerable.

The streambeds are littered with boulders which have rolled down the steep slopes, and with trunks of aspen trees which are plentiful and of good size along the streams. The debris shows no evidence of erosion and it may be assumed that powerful floods have not occurred in either watersheds for many years. In many places the streams are invisible, flowing under the loose boulders. This feature is more marked in Watershed B than in A. A notable feature is the short branch stream coming in from the north about 400 feet above the dam on Watershed B. This comes from a spring, the water having apparently been carried on the lava substratum from higher portions of the watershed, breaking out where the lava outcrops. There is, however, no reason to suppose that the water comes from without the watershed.

The primary work of the streamflow study is the accurate measurement of the two streams involved, continuously and without error through all

seasons for a number of years. The secondary work of the study includes the measurement of precipitation, temperature, and other meteorological factors which may affect the flow of these streams. The accuracy of the streamflow measurements depends upon two factors, viz., the structure of the dams and the construction and manipulation of the automatic stage register and the check measurements made by hand.

The streamflow measurements should be considered first. In order that the purpose of each of the various structures involved may be understood at the outset, it will be well to enumerate the points which are to be reached by this experiment. It is desired, first, to determine the total run-off of each watershed in cubic feet per annum, finally expressed as a percentage of the total precipitation on that watershed and as a supplement to the calculated evaporation. The soil evaporation and transpiration from the trees will be affected by the later denudation of Watershed B, and the total run-off will be affected in the opposite direction. Second, it is desired to determine the time and degree of the flood and low-water stages as related to precipitation and thaws of given intensity. For such a study, only continuous records of the discharge of the streams will suffice. Such records may be obtained by measuring the height of the water over a weir and expressing this measured depth, by means of a formula, in cubic feet per second. Third, the amount of silt carried by each stream and deposited in a settling basin is to be determined. This supposedly will be affected by the deforestation of Watershed B. The measurement, by weight, of the silt deposited in the basins is to be supplemented by physical analyses of the water which passes out of the basins.

Each dam is necessarily located at the lower extreme of the watershed involved. Narrow points in the canyons were selected for dam sites, considerably above the Rio Grande bottom. The structures on the two watersheds are identical in every essential respect. There are four important parts of each dam, (1) the dike, (2) the basin, (3) the weirs, (4) the still-wells.

1. The dike is expected to raise the surface as well as the subflow of the stream to an opening slightly above the original streambed, in order that all of the water may be measured. To this end a concrete wall was sunk to the impervious stratum underlying the loose soil, rock, and debris of the streambed. In Watershed A this stratum consisted of lava rock on the north side of the stream and stiff yellow clay lying in a bed over the rock on the south side. This clay was several feet below the streambed. Hence, to raise the water to the desired level, it was necessary to extend a wing of the dike upstream until the proper level

was attained. The concrete in contact with the clay substratum is just as effective in checking the subflow as though it were on bed rock, which in this case lies at considerable depth, being covered with an immense slide deposit of loose rock and sandy loam. In Watershed B the entire length of the concrete dike rests on granitic bed rock. The opening at the center of the concrete dike is trapezoidal, 2 feet wide at the bottom, the walls sloping about 30 degrees from the horizontal for a distance of 2 feet. Beyond this the walls of the dike rise gently toward each end.

2. Through the opening in the dike the water pours in a thin, broad sheet into the basin. The basin is trapezoidal in ground plan, being only 6 feet wide at the upper end, while the lower end, which is supported by a cribbing of logs filled with rock, is 18 feet wide. The length of each basin is 25 feet and the total depth 4.5 feet. However, the water begins to pass out of the basins when a depth of 3 feet is attained and the additional foot and a half is only necessary to provide room for the water in case of floods. The capacities of the basins are proportional to the areas of the watersheds. Basin A has a capacity, to the weir, of 888 cubic feet, while Basin B will hold 846 cubic feet before the water begins to pass over the weir. Hence, under normal conditions, the waters of the two streams have about the same amount of time for settling. Under the low-water conditions existing in September, 1910, three or four hours were required for a complete change of the water in the basins.

The walls of the basins are of concrete, 5 or 6 inches thick, and faced with a rich mixture of sand and cement. The floors are equally thick and are capable of withstanding a great pressure of water. In the southeast corner of each basin there is a depression of about 1 inch in the floor, to facilitate draining when it is desired to remove silt from the basins. When the basin is to be drained the stream may be diverted through a 4-inch iron pipe from a point in the streambed just above the dike to a point below the dam.

3. Having stood in the basin until cleared of silt, the water passes out over a weir without appreciable velocity. At each dam there are two weirs; the first 12 inches wide, its crest 3 feet above the bottom of the basin; the second, 24 inches wide, its crest 6 inches higher. The latter is a storm weir and is not expected to come into play except at times of very unusual discharge. The water begins passing over the larger weir when it is 6 inches deep over the smaller one. It is only necessary to know at any time the height of the quiet water in the basin as compared with the level of the small weir to calculate the discharge from each weir and the sum of the two.

4. The still-wells are simply vertical tubes connected with the main body of water in the basin. In these tubes, which are merely cavities in a concrete block, the water stands undisturbed by wave action, which would prevent accurate measurements in the larger body of water. The concrete pier is 39 × 22 inches at the base. One foot above the base there is a 4-inch iron pipe with both ends open into the water of the basin and with two vertical openings into the two still-wells. The larger still-well is 5 feet deep and 10 inches in diameter. Over its upper opening the automatic stage register rests upon the concrete. The smaller still-well is only 2 feet deep and 4 inches in diameter. The surface of the water in this tube is visible from above and the level of this surface, as determined by a hook-gauge, represents the actual depth of the stream which passes over the weir.

All the water of the stream passes into the basin and is to be measured as it passes out over the weir. The hook-gauge measurements show the level of the water in the basin as compared with the level when the water begins to flow over the weir. An accurate measurement of this sort is made only as a check upon the automatic instrument which is designed to show every minor fluctuation of this water level. These fluctuations, of course, indicate variation in the discharge of the stream in which the time element is no less important than the element of quantity.

In the Friez River stage-register a continuous record of water level is made by a pen upon a ruled sheet which is wrapped about a drum. This drum is revolved by the rising and falling of a float in the larger still-well, these fluctuations corresponding to those of the surface of the water in the basin. The zero point on the sheet represents the level of the weir crest. Variations from this level may be accurately read on the sheet to one-thousandth of a foot. The time element is indicated by the movement of the pen across the sheet from left to right, actuated by clockwork. A single sheet carries the record for one week. The time of any specific part of the record may be determined with an error not exceeding ten minutes.

It is expected that the automatic instrument can be operated throughout the year by using in the winter a light oil which will not freeze on the surface of the water in the still-well. It is known that the streams, when both watersheds are covered with a normal amount of snow (which is 3 or 4 feet in midwinter), continue to flow during the coldest weather. This water probably has a temperature several degrees above freezing and it is expected that it may be kept from freezing in the basin by preventing radiation, and that the weirs may be kept open. To this end

each basin has been covered with a flat platform supported by heavy joists which are capable of holding the immense load of snow which in turn will serve as a blanket for the water in the basins. Over the top of the concrete pier, which projects a foot above the level of the plank covering, a small shelter house has been built to protect the automatic stage register and the observer who must adjust it in the coldest weather. Within this house there is a trap-door in the floor which permits the observer to reach the surface of the water in the smaller still-well for the purpose of making hook-gauge measurements.

In the event of the freezing of the water which would prevent the operation of the stage register, the ice must be broken daily and a hook-gauge measurement must be made while a normal flow can be maintained over the weirs. Since in extremely cold weather fluctuations of discharge would be very slight, a single daily measurement of this kind will suffice to give the total discharge for the period.

The auxiliary meteorological records, explaining in a scientific way the behavior of each stream as shown by the records of the stage register, are to be obtained at a number of stations.

Near the lower end of each watershed in the forest on the north slopes is located the main meteorological station for that watershed. These stations are designated A-1 and B-1, respectively. Their equipment is very complete and is intended to show every fluctuation in the temperature of the air and the soil, the maximum and minimum temperatures each day, fluctuations in the atmospheric humidity, the rate of evaporation from a free water surface, the rate of wind movement in the forest, and, most important of all, the exact amount of precipitation in the form of rain and snow, and the time at which it falls.

Opposite these primary stations on south slopes are secondary stations, designated A-2 and B-2. Their equipment will give only the maximum and minimum temperatures for each day and the total amount of rain and snow. Both the primary and secondary stations, however, will be visited every day.

At a point which represents conditions at the upper extremes of both watersheds, there is a third primary station which will be visited semi-weekly. From its instruments will be obtained a continuous record of the air and soil temperatures at that (high) elevation and the maximum and minimum temperatures for whatever period may elapse between successive observations. Here, also, the amount and time of precipitation will be recorded, since it may affect the flow of both streams.

A fourth primary station is located near the headquarters and will furnish all of the data ordinarily obtained at a first-class Weather Bureau station.

In addition to these stations there will be about 15 snow scales on each watershed, covering the entire area and furnishing a basis for an accurate estimate of the amount of snowfall and its rate of melting.

Of all the factors to be measured none will be of such direct importance, in its effect upon the character of the discharge of the two streams, as precipitation. The measurement of rainfall will be carried on at three stations for each watershed. At two of these automatic records will be obtained which will show the time relation of storms and floods. This measurement is comparatively simple, while the measurement of snowfall and the rate of melting of snow is a much more intricate work. By using a freezing solution in the evaporation pans which serve also as rain gauges, it will probably be possible to obtain a direct time record of snowfall expressed in its water equivalent, in the spring and fall when there is likely to be melting and run-off. During the colder part of the season, however, when thawing occurs only on the surface of the snow, the numerous snow scales must be depended upon to furnish a mean figure for the depth of snow on each watershed, its accumulation, and disappearance by melting and evaporation. The snow scales will all be read semi-weekly, and at the same time a vertical sample of the snow, on the ground at each scale, will be obtained and its water equivalent calculated by weighing.

Air and soil temperatures must necessarily be measured, since they affect primarily the melting of snow and consequent floods, and affect secondarily the evaporation of rain water, soil moisture, water in the trees and in the streams. Thermograph records showing all of the fluctuations of temperature will be obtained at each end of each watershed and will show the number of hours each day when thawing is possible. Of no less importance are the thermometers placed at a depth of 6 inches below the surface of the ground which will indicate the possibility of the melting of snow banks from beneath or of the accumulation of ice from snow melted by the sun's rays. Both air and soil temperatures will have their greatest effect upon streamflow when the snow is melting; but it has already been demonstrated at Wagon Wheel Gap that there may be a daily fluctuation, on account of temperature, amounting to 18 per cent of the minimum discharge of the stream.

The rate of evaporation from the surface of the water in a 3-foot pan is to be determined at one point on each watershed for the purpose, first, of giving a general estimate of the amount of water lost by evaporation from the soil and transpiration from the trees in different seasons, as compared with the total precipitation; and, second, for a comparison of the rate of evaporation on a forested and deforested area. Fairly accu-

rate measurements in Europe have shown what relation exists between the rate of evaporation from a free water surface in the forest and that from various kinds of vegetative cover.

The relative humidity of the atmosphere as it may affect the rate of evaporation will be determined by hydrographs at one station on each watershed and by check readings of the psychrometer at several other stations.

The rate of wind movement will be measured in the forest, since it may affect the evaporation from the pans and will also be determined along with wind direction at the headquarters. The general direction of the wind, whether from the mountains or from the valley, has a direct bearing upon changes in temperature.

The numerous streamflow and meteorological records obtained will be recorded not only upon the usual Weather Bureau forms which will be available to any student of the subject, but will also be immediately worked up into a continuous graphic record. For each watershed this graphic record will consist of curves showing the discharge of the stream in cubic feet per second, the current rainfall for half-hour periods, the water equivalent of snow lying upon the watersheds, the fluctuations of air and soil temperatures, the rate of evaporation from the free water surface, and the amount of detritus carried by the stream.

From considerable experience in the expression of natural phenomena in the form of graphic records, I feel certain that the correlation of all of this data in the form of paralleling curves will furnish the clearest index of the relation of all the physical factors to streamflow. A multitude of figures is usually confusing, while the same figures expressed in the form of curves may be very elucidating. Thus, in obtaining a comparison of the discharge of the two streams before and after the denudation of Watershed B, first reference will be made to those graphic records in the search for similar sets of climatic conditions. Having found these and determined the character of their effect upon the streamflow, the more accurate data may again be obtained from the tabulated figures.

The experiment which I have described to you is the only one of its kind that has ever been instituted, except the Emmenthal experiment in Switzerland, near Zurich. It must, I believe, always stand as an example of the scientific thoroughness in the solution of forestry problems, which can only be obtained by concentrating the efforts of experts at permanent experiment stations, on the ground. The length of time involved in this experiment must be determined entirely by the occur-

rence of a variety of climatic conditions. Whether it be ten years or twenty, its results must affect a large number of people, and I believe that it has a claim to recognition by all those who are interested in the problem, whether they be foresters, meteorologists, engineers, irrigators, or merely farmers on river bottoms subject to inundation. Its completion will, I hope, put an end to the meaningless discussions which have been so much heard in recent years.

THE PHILIPPINES AS SOURCE OF GENERAL CONSTRUCTION TIMBERS

DR. H. N. WHITFORD

(*Contributed*)

Recent investigations of the Bureau of Forestry in the Philippine Islands have developed some interesting facts concerning the nature of the forests of these Islands. It has been roughly estimated that the amount of standing timber in the Islands will reach at least 200 billion board feet. The area of the Islands is approximately 120,000 square miles. About one-third of this, or 40,000 square miles, is in virgin forests. These may be divided into the following forest types:

1. **Lauan type.**	Dipterocarp types
2. **Lauan-hagachac type**	
3. **Yacal-lauan type**	
4. **Lauan-aptiong type**	
5. **Tanguile-oak type**	
6. **Molave type**	
7. **Pine type**	
8. **Mangrove type**	
9. **Beach type**	
10. **Mossy type**	

It will be noticed that the first five of these types are grouped under one name, viz: *dipterocarp*, because the characteristic trees belong to the Dipterocarpeæ, the principal tree family of the Philippines. It is distinctly a tropical family, confined to the Indo-Malay region. The estimated stand of timber in the dipterocarp types is 192 billion board feet as contrasted with 8 billion board feet distributed among the other types. Within the dipterocarp types approximately 75% of the total or 144 billion board feet of the standing timber belong to members of the family that gives the type its name.

The dipterocarp types are found on nearly all kinds of topography, from immediately behind the frontal zone on the beach to an altitude of approximately 800 meters on the slopes of the largest mountain masses. From the standpoint of the botanist the composition of these forests is complex, but from the standpoint of the lumberman it is comparatively simple.

Practically all the species of the dipterocarps are large trees, reaching heights of 130 to 180 feet and from diameters of 3½ to 6 feet. They

have straight, regular boles resembling in size and shape the yellow poplar of the United States. Some of the tree species of the other families have a size and form similar to the dipterocarps, but by far the greater majority of sub-dominant species, many of which have ill-formed boles, are much smaller in diameter and length. From a botanical point of view these add greatly to the complexity of the forest, but for commercial considerations they are not very important.

Some idea of the relative importance of these trees can be given by reference to certain stands in different parts of the Islands where valuation studies have been made. A large area in the Island of Negros shows a stand of approximately 45,000 board feet per acre, 43,000 of which are members of the Dipterocarp family, comprising about six different species. This forest grows under the very best conditions at the foot and on the lower slopes of the mountain. The soil is not too dry and the drainage is good, so that there is not an accumulation of an excessive amount of soil moisture.

The delta plain in the Island of Mindoro shows a stand of approximately 16,000 board feet, about 9,000 feet of which belong to the dipterocarp family. In this situation during the rainy season the soil on large areas is very moist, which is presumed to be a detriment to the best development of the forest. Certain species of dipterocarps, however, are adapted to these conditions and one at least seems to thrive in no other place.

Again, an area on dry, coastal hills in the Island of Mindanao shows a total stand per acre of about 29,000 board feet, 14,000 feet of which belongs to the dipterocarp family. Here, again, certain species of the dipterocarps are found adapted to the shallow, rather dry soil of these coastal hills, and if found elsewhere are only poorly developed.

Certain regions of the Philippines have a pronounced dry season. Other regions have no dry season or one so short that its effect upon the forest is not marked. The above described forests occur in regions where the latter climate prevails. Another type of dipterocarp forest occurs in regions where the dry season is rather pronounced. In spite of this the dipterocarps still maintain an ascendancy over all other species. For instance, a large area in the Province of Bataan shows a total stand of about 28,000 board feet, 19,000 of which belong to the family under discussion.

A large number of other instances could be given where the predominance of this family is shown, but enough examples have been cited to show that the conception of tropical forests so far as the Philippines are concerned must be changed. The studies made in the Philippines show

clearly the predominance of one family of trees. This family contains about 35 different species. Of this 35, 12 or 15 are by far the most successful. These occur in so heavy stands that modern lumbering methods can be and are being used to extract them.

It has been maintained that the Tropics produce no timbers suitable for general construction timbers; that the wealth of the tropical forests is not in general construction timbers, but in those of the mahogany and teak grades, and that such trees are so scattered that the expense of extracting them is very great. It is shown above that the dipterocarp timbers are in sufficiently heavy stands to be extracted by the aid of machinery, and that the members of the predominating family are tall, straight-boled trees and free from knots. The question now arises, what is the character of the wood of the species of this family?

From the standpoint of the lumberman, the woods of this family may be divided into three groups, namely: the lauans, the apitongs, and the yacals. About ten species of the dipterocarps furnish the wood that can be classified with the lauans. These woods vary in color from a light, creamy, and other shades of brown to red. They are soft to moderately hard and light to moderately heavy. They are all coarse, but straight-grained, free from knots, easily worked and in general mechanical properties are not greatly dissimilar to the pines and their allies. When quarter sawn or slash sawn with a figure, they show a beautiful grain. They are readily attacked by fungi and white ants, but not more so than is Oregon pine—their chief competitor in Philippine markets. When they reach the market they are usually sold under one of three woods, namely: white lauan, red lauan, and tanguile. Locally they are used for a great variety of purposes. They are especially adapted for light and medium construction work, in which they find their greatest usefulness. In this respect they are to the Tropics what the lighter grades of pine are to the temperate regions. Nevertheless, for many classes of construction, because of their color and beautiful grain, they are superior to the pine. This is especially true for interior finish of all classes. The better grades of lauan and tanguile for this reason are now finding a ready market in the United States under the trade name of Philippine mahogany. No less than one-half of the standing timber of the Islands are lauans. It is by far the most important group of timber in the Islands.

About four species are the principal source of the wood known as the *apitongs*. They grade in color from dirty, brownish-red to red. In hardness they are moderately hard to hard. In weight they are moderately heavy. They are usually coarse and straight-grained. They are used for many purposes, but are especially adapted for heavy construction where

contact with the ground is not necessary. For general construction qualities the *apitongs* are comparable to the hard pines of the temperate regions. In abundance, they are next in importance to the lauans.

The third group of woods of the *dipterocarp* family, known as the *yacals*, come from about six different species. They are usually yellowish-brown in color, becoming darker with old age. They are hard and heavy. They are as free from the attacks of white ants and fungi as any so-called durable wood used for construction purposes. The *yacals* are general all-round construction timbers where contact with the ground is necessary, and because of this are much sought for railroad ties, paving blocks, and house posts. They are also used as bridge timbers, in various parts of ships, and for construction of houses. It is estimated that there is more standing timber of the *yacals* in the Islands than all the other so-called standard durable timbers put together.

The above studies show that the chief supply of timber of the Philippine Islands comes from species of woods that can be used for general construction purposes, and that such woods are found in sufficient abundance to warrant their extraction by modern methods of lumbering. Thus it will be seen that the usual idea that the Tropics do not produce construction timbers in heavy stands does not hold for the Philippine Islands. It may be that the Philippines are unlike the other Tropics in this regard, but the author is inclined to believe that our knowledge concerning tropical forests of other countries is not sufficient to warrant the statement that they do not contain cheap construction timbers in large quanities. The notion that the Tropics in general contain only hard, durable timbers, scattered, and hard to extract, comes not from a systematic study of the forests, but from what has been taken from the forest and placed on the markets of the temperate regions. A vast majority of the timbers used in the Indo-Malay region is mainly from the family of *dipterocarps*. They are the chief general construction timbers. As a rule, the more durable timbers of this family are sought because they are more resistant to the attacks of white ants and fungi. Nevertheless, in the Philippines the largest consumption of timber for local purposes is of the varieties of woods produced by this family that are neither durable nor resistant to the attacks of white ants and fungi. It is believed that treatment with preservatives will render such timbers much more useful.

ECONOMIC POSSIBILITIES OF PINUS SABINIANA

CHARLES H. SHINN

(Contributed)

The range of this sun-loving pine of the Californian foot-hills is so wide, its endurance of thin, dry soils is so extreme (and its response to better conditions so marked), that it seems to justify care and study.

Of course all students of the Californian semi-arid foot-hill conditions recognize the silvicultural importance of P. sabiniana in helping to extend forest conditions further toward the valleys, but hitherto our writers have generally stopped with this, and have accepted the pioneer view that the tree is really worthless commercially.

It is perfectly plain to all of us that P. sabiniana has not been utilized anywhere, excepting in very small and haphazard ways (and by some miners on a large scale for "props" in "wet" mines, where the timber is very durable). In fact, for many years the tree appears to have been wholly neglected as one which yields neither lumber nor firewood. We have, however, a lesson in the economic history of the lesser eucalypts. Von Mueller, Bosisto, the Melbourne Technological Institute, and other people and forces worked half a lifetime on the essential oils of species long held utterly worthless before the world's markets began to respond. Something like this may prove to be the history of long-neglected American trees such as P. sabiniana. If we question them long enough we shall get our answers.

Botany and Habitat of P. Sabiniana

This species is held to belong to the white pine sub-genus, not to the yellow or pitch-pine group. Some of the botanists regard it as a real genus, and certainly the small arid-zone nut-pines taken as a whole seem very well separated from the white pine and the yellow pine groups. The degree of separation has an important bearing on the problem of cross-fertilization—i. e., of the possibility, or otherwise, of producing valuable hybrids for the forestry of the future.

Pinus sabiniana, or the "gray foot-hill pine," is one of the most characteristic trees of nearly the whole foot-hill belts of both Coast Range and Sierra. It endures a summer temperature of 115° Fahr., and a very low winter rainfall. In the Huero Huero region in San

Luis Obispo, where the rainfall never exceeds 15 inches and often is below 6 inches, this pine grows so abundantly and well that the first settlers built a small mill and sawed all the lumber for their cabins.

My own observations show that in seasons of very severe drought, when some of the native oaks died (rainfall of two successive years amounted in total to less than eight inches), the digger pines continued to flourish in the most arid portions of the Coast Range. Where the soil is deep and the roots can descend, such a tree has immense drought-resistance. Fifteen inches of rain, on the porous granite of some of the Sierra foothills, is less useful to a tree than four inches on the clays of the Coast Range.

The botanists note with interest that this pine is entirely lacking over large areas where it would naturally thrive; there are remarkable "breaks" as one comes up the mountain ranges from southeast to northwest. The geologists may be able to find some clues to this, but unless some cause once stripped those areas of vegetation, one can not now see why P. sabiniana should grow so abundantly north of Kings River and south of Eshon Valley, but not between these points.

The Huero Huero Saw-mill

In the Huero Huero region the settlers sawed their lumber from this species. An English colony bought land from a Spanish grant, in a "wheat" year (one of heavy rainfall). The colonists put up cabins, blacksmith shop, store, etc., and many board fences, from this lumber, and they are still in use. Three or four other cases in which this pine was sawed by settlers have occurred in California. In order to obtain fair second-grade lumber for ranch use, the logs must be peeled as soon as felled, and sawed when a month or two down; the board should be seasoned in the shade under heavy weights.

Natural Size and Age of the Tree

While the authorities have differed widely on these points, close field study will convince any one that some injustice has been done this species by most of the statements hitherto printed about it.

Silvical Leaflet No. 33, says: "Small" and "under 60 feet," and "from 12″ to 18″ in diameter." Sudworth says 18″ to 30″ in diameter and notes the usually bent branching growth of isolated trees. He thinks that full growth is from 60 to 80 years.

Now, these sizes and age estimates are much too low. The tree frequently attains a diameter of 4 feet. Dr. Kellogg, in "Forest Trees of

California," mentions a tree 5 feet in diameter, and he secured very careful measurements.

One tree of which a record was taken this year by Ranger Mainwaring, had a diameter of 46 inches. Its age was 85 years. The height was 90 feet, though it had a much broken top. Under normal conditions this tree might easily have reached a diameter of 5 feet and a height of 120 feet. Other tree records sent in by Ranger Clark were as follows:

No. 1—Diameter 33". Age 152 years.
No. 2—Diameter 26". Age 90 years.
No. 3—Diameter 16". Age 45 years.

These three were on much poorer soil than in the case of the Mainwaring tree. But all through the Sierra foot-hills there are trees of upwards of three feet in diameter, ranging in age from 80 to 175 years, and in height from 75 to 110 feet. These trees stand in rather better soil, and sheltered, not on the exposed points. We cut one tree to creosote for a telephone pole, in such a barren place, and with a diameter of 8 inches it showed 95 rings. Half a mile distant was a 4-foot tree, with the same rainfall and climate, but on better soil, and certainly of less age.

There is hardly a pine in California which makes quicker growth in youth, under favorable conditions, nor any, except it be the lodgepole, which sooner reaches the cone-bearing age. There is need of more complete tree-records on this species from all parts of California at different elevations and in different soils, before we reach final conclusions as to age and size.

Causes of Neglect of this Tree

When a pine of very poor appearance and much scattered growth occupies foot-hill belts, along which many pines and easily accessible species grow, and when the native oaks furnish a better fire-wood, it is of course inevitable that all its dormant possibilities are neglected, that it is despised by every settler, that it is called "poisonous to the soil" and a "detriment to the country."

Under these conditions many and suggestive instances of profitable uses of this tree are completely overlooked. Therefore we are tempted to go afield, to other lands, looking for hardier, drought-enduring pines to take the place of this highly tolerant native.

But with the suppression of fires in recent years, the yellow pines have moved down the creeks and ridges, and the digger pines have moved up a little here and there. Their common territory is thus somewhat more definite than it was ten years ago. If ever a true hybrid occurs

(a much to be desired but profoundly difficult and unlikely thing), it will be in this overlapping zone (mainly about Jerseydale, Northfork, and in Jose Basin, in the Sierra National Forest).

One of the principal reasons why this tree has been so much neglected by foresters is because of its branchy habit of growth. This certainly appears natural, for it predominates throughout California, and yet there are abundant signs that similarly hard, but not unavoidable local conditions are chiefly to blame.

Our frequent foot-hill fires and the fondness of rodents (and Indians) for the seeds, drove the sugar pine to the rocks and canyon heads, and that made its growth chiefly in isolated, much-branched specimens. Saw-logs became impossible to find, though in the early fifties this lumber was frequently used for inside finishing, and is often a really beautiful wood. P. ponderosa, grown under similar conditions, as on the Inyo side, and low down on the Western slope, becomes similarly difficult to utilize—"one saw-log to a tree." Moreover, the difficult struggle for life that this half-savage pine of the foot-hills has undergone, makes it unusually susceptible to attacks from fungous diseases and parasites; it somehow struggles through every foot-hill fire, scarred, broken, and wounded, but mistletoe and fungi assail it constantly.

The tree has also been neglected because of the very rapid decay of its wood when exposed to "wet and dry" conditions. Posts from 6-inch poles rot entirely off in one or two seasons, and frequently are a mass of fungi at the surface of the ground in less than three months after the rains begin. Split posts are little, if any, better. While creosote treatment should remedy this, the interesting fact is to be noted that the "oleoresin" of the digger pine does not permit creosote to enter deeply or easily, and a lot of experimenting seems necessary before a really cheap and effective process for making digger pine a substitute for redwood and cedar as posts will be found. Unless such process is found, digger pine posts will be of little value to the foot-hill farmers, as the table below illustrates:

Comparative Cost (Retail) of Posts on Farm

Species.	Cost per 1000 posts.	Average natural durability.
Coast Redwood (*Sequoia sempervirens*)......	$250.00	20 to 25 years.
Mountain Cedar (*Libocedrus decurrens*).......	200.00	15 to 20 years.
Digger Pine (*Pinus Sabiniana*)...............	100.00	1 to 2 years.

The above prices are averaged on the cost at a number of farms in the San Joaquin Valley about equidistant from the railroad and the foot-

hills. The redwood must be hauled from the station; the cedar must come down from the cedar belts of the Sierra; the digger pine is the "short haul."

All the authorities agree that the digger pine has a high fuel value, especially for furnaces, so much so, theoretically, that it is indicated as by far the cheapest and best for steam-power houses in the foot-hills, and, if near a railroad, it could be utilized in the place of oak. But it must be mainly handled by machinery, not with the axe, as the interlocked, irregular wood-fibers render its cutting difficult and expensive. This has gone far to prevent its use for fuel by the pioneers. It is said, however, that it splits much better when "half-dry" than when green or entirely dry. Trees normally developed under forest conditions would cut and split much more easily than the many-branched isolated specimens which now form the bulk of the older sabinianas in the foot-hills. Even now, individuals vary greatly in this respect. These are specimens which are as straight-fibered as a good yellow pine.

Probable Increase of this Species

It is only within the past few years, or since the establishment of the National Forests, and an awakened public interest in checking the foot-hill fires, that P. sabiniana has had much chance to show its real characteristics of growth under favorable conditions. It seeds so abundantly, and every season, too, that if fires are prevented, and if something can be done to lessen the damage from rodents, this pine is likely to considerably increase its area, and also to greatly increase its density of stand.

Our foot-hill oaks show a great deal of decrease, and little reproduction, and are rapidly disappearing under the increasing local demand for fuel. This pine, and the larger shrubs, must aid in the fuel-supply within five years. The steady increase of foot-hill pine, which in its earlier years grows up through the thickest chaparral, is a very important economic asset to this region.

The strict limiting of the number of hogs allowed to graze at large gives this pine a better chance, and also helps the oaks, as hogs eat all the pine nuts, as well as all the acorns they can find. In fact, if tree seed in the foot-hills is worth even five cents per pound, a band of hogs soon destroys five dollars' worth of seed per animal.

But in spite of all these local difficulties, Pinus sabiniana is spreading more widely through the oak and chaparral belt in a noticeable way, and one finds more "thickets" of young pines now than ten years ago. There

are still no closely grown P. sabiniana groves, but with continued protection from fire such groves might appear eventually.

Some Needed Investigations

The stand of this pine has never been estimated separately, any more than that of the alpine pines, such as Balfouriaria and Monticola. All of the foot-hill growth runs together as cord-wood. But, in view of the larger areas affected, in and near the forests, the probable development of new economic uses, for such products of this pine (as the oleoresin), and also the increased growth of this species, a number of studies of selected areas are advisable. These areas should be chosen on different soils at different elevations. Some should properly be fenced and protected; others should be under natural conditions.

First—*Sample Areas.* It is important to know the extent to which the density of the stand of Pinus Sabiniana is increasing under favorable conditions. (The first rude attempts to control fires on the Sierra Forest were in 1899; in 1903, these efforts became much more definite.) Now, as far as my observation goes, the bulk of the young trees are 10 years old and younger, and each year of good rainfall, better reproduction shows.

Grazing of hogs in the Forest was brought under some control in 1903. The Forest was extended in 1908, taking in more of the foot-hills, and county fire-wardens have more or less protected the Western border since then.

Second—*The Soil.* P. sabiniana on adobe, or stiff clay, or on long-abandoned farms, once plowed, but now reverted to woodland, makes an even upright, and more dense growth. Even in thickets of this pine, however, the lower branches are remarkably persistent, because so much light sifts through the loose, open tops. Still I can see no silvical reason why saw-logs could not be produced under these conditions if desired, especially for construction timbers, the strongly indicated best use of this tree.

Third—*Loss of Leaders.* This pine is very subject to loss of the leader, from insects, fungous diseases, or especially brittleness of young growth early in the season. Last February, in one day's ride along the border of the yellow pine and digger pine country, many digger pines were noticed to have lost the leaders, and were replacing them with several lateral branches, no one of which was suppressing the others. Brittleness was here apparently the principal cause, as the losses were almost entirely on the windy ridges, and not in the sheltered hollows.

But in the Coast Range (Santa Lucia Mountains, San Luis Obispo County) and in the Shasta and Tehama foot-hills, many leaders of Pinus Sabiniana are destroyed by two microscopic fungi, one whitish, the other orange colored, which form knots and swellings on the leader several joints from the tip. The California Academy of Science investigated these some twenty years ago; the first was called Dædalia vorax, and the second Peridermium harknessi. It might be that the peculiar gaps observed in the distribution of this pine along the Sierras are due to ancient assaults of these microscopic enemies.

Fourth—*Seed Sowing.* The best way to produce a dense growth of this pine is to establish it artificially. There ought to be no further delay in this matter, for a five-acre grove would soon solve the problem as to the possibility of establishing cheaply and rapidly dense stands of this species. It seems to me that we can,—that no other pine is so well adapted to the lower foot-hills, nor so capable of improvement in respect to stand.

Fifth—*Timber Observations and Tests.* Specimens should be obtained from the Coast Range, and the Sierras, at different elevations, on different soils, and from trees grown under both forest and woodland conditions. These specimens will doubtless exhibit a great variety of results—greater than that obtainable from any other California pine.

The timber of this pine has been variously described by writers, Kellogg, Lemmon, Parry, Gray, Sudworth, Sargent, and others as "white," "brown," "reddish," etc. It seems to me brownish, and of most varying texture. The isolated trees, of course, yield a very coarse-fibred timber. Trees grown closer, yield much finer-grained and softer wood. The timber of such trees was used in California for many years for ox-yokes and is preferred to any other wood for that purpose. Very marked is the probable value of this pine for construction timbers, especially bridge-work, when so treated as to preserve it. Kellogg lays stress on the value of this pine for saddle-tree and many other farm uses. I have myself seen it preferred to oak and ash for plow beams and wagon bolsters. The California miners have used much of it underground for props wherever it remained wet all the year.

Modern conditions seem to require more cheap, low-grade, easily accessible, and rapidly grown lumber, as well as the standard species. A tree which averages 2 feet in diameter and often reaches 4½ feet, which grows at the door of the foot-hill settlers, and whose yearly increment is especially high, would seem to justify careful and long-continued experiments upon its timber.

Products of the Tree.

The Nuts. The few species of nut bearing pines in the United States and Mexico, principally P. monophylla, P. quadrifolia (formerly P. parryana), produce such edible and rich nuts, capable, one would suppose, of improvement in size, if the work were taken up by horticulturists, that it seems as if something might be done to develop an industry, and supply a wider market. Roasted pine nuts are for sale in a few local markets, and are delicious, but the supply is not yet reliable. The nuts of Pinus pinea fragilis, a variety of the well known Italian stone pine. form a profitable crop in Southern France.

The various "pinon" nuts divide into two classes, the "thin-shelled," which can be crushed between thumb and finger, and the "thick-shelled," which require a hammer. Though "thick-shelled" as is the P. coulteri seed, the nut of P. sabiniana is one of the best. In time the leading pine nuts will perhaps have a steady market value for food in this country as elsewhere. The Nepalese native proverb in relation to P. gerardiana, the Himalayan nut-pine, a tree 40 to 50 feet high, is that "one tree keeps a man all winter."

The Oleoresin. The tree when properly tapped in the spring yields oleoresin, which is generally called its "turpentine," and which has interested many chemists in America and Europe.

Sierra Forest has for several years supplied some oleoresin, at mere cost of collection, to various chemists, in quantities of from a pint to several gallons, and has sent small samples without charge. Small earthen flower pots, plugged at the bottom, were used instead of the regular turpentine cups.

There are two flowing seasons here. One opens very early and ceases when the weather grows hot; the other is in full current in the middle of August. It will pay to tap the trees for several months a year, and that a good tree properly handled might yield from one to three quarts in a season. The trees are so scattered and of so many age-classes that the commercial handling of this product on a large scale only seems practicable by securing a definite market price per barrel; by interesting small foot-hill farmers, prospectors, trappers, and such persons in collecting the oleoresin by small, inexpensive outfits.

The market value of oleoresin is not yet known, as no definite price has yet been fixed. Beginners probably could afford to take contracts to furnish it at a dollar a gallon, and might in time cut under this. A definite market, at a price which would pay fair wages to the workmen, for anything like five hundred barrels a year, would soon set fifty small outfits at work in the foot-hills.

It seems evident that some satisfactory laboratory results have been reached in several places, as regards oleoresin. "Science" noted lately that a product of oleoresin is now proposed for making the higher grades of linoleum, and that it can be so treated as to make a substitute in some directions for India rubber. As oleoresin now goes to the Madison laboratory, we shall doubtless know more about it before long.

Abietine, etc. As all the pines come under the general family name of Abietinæ, the application of this term to the extract first put up and sold as medicine, by an Oroville druggist some thirty years ago, is not surprising. This product is said to pass under the names, also, of "evasine," "aurantine" and "theoline." * When these products were first on the market, curiosity was stimulated by the myth that "an exceedingly rare conifer unknown to botanists" had been found (one small grove in Butte County) and that "Abietine" came from thence.

Other Products. If the pines are tapped on a large scale, there will be many dead trees before long, for firewood and for tar, and hence experiments should be tried later with a tar-pit.

Some fifteen years ago parties near Northfork cut the large roots of pine, and obtained by distillation some twenty barrels a year of a very high-grade turpentine. This they sold by contract to the Alaska Fur Company, where it was much liked by one of that firm's large buyers. When he died and the little still burned down, the manufacture ceased. I had samples of this product in 1903, but at that time thought it a yellow pine resultant. There may have been some yellow pine in it but the P. sabiniana was the principal wood.

Résumé. These facts seem to justify that studies of this pine be taken up along definite lines, in several selected forests in both Sierra and Coast Range. Monterey, Shasta, and Sierra are three of the best points for this work.

Seed should be collected and small plantations should be established on different soils.

Selected timber should be tested for bridge construction. Exhaustive creosote and other treatment tests are advisable.

Pines of similar drought endurance, principally from Western Mexico, ought to be experimented with. While there are no true pines in Chile, or any part of South America, some conifers of foot-hill values might be found by corresponding with botanical gardens.

Work with the oleoresin and other products of P. sabiniana should be continued.

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*"Garden and Forest," Vol. X, page 202.

Lastly, other lines of investigation will develop if these are begun. The larger hope—that steps may be taken toward hybridization of pines—must depend entirely on finding a capable investigator and continuing his work long enough to get results. No one knows what the chances of success are, and many botanists would say that it can not be done. Hybrid firs (Abies) have been observed and described in Europe. Hybrids of Pinus Silvestris and P. insularis have been found in the Swiss Engadine. Hybrids of Pinus thunbergii and P. densiflora have been reported from Japan. But in this case what forestry needs is a commercially satisfactory hybrid between Pinus sabiniana and Pinus ponderosa, which shall practically extend the profitable area of the latter. In order to obtain this result the right person must try to produce crosses both ways and bring the seedlings to bearing age, test the wood without destroying the trees, and propagate every valuable hybrid.

Since this is a matter of fifty years or more, this work should be taken up by a Forest Experiment Station, which should secure all possible observations bearing upon hybridization of pines, and should study the characteristics of seedlings wherever different species are found in juxtaposition.

We cannot go further now, but this much, at least, we should not fail to do.

HISTORY OF THE INVESTIGATIONS OF VESSELS IN WOOD

C. D. MELL

(Contributed)

Introduction

The vessels of secondary wood are elements that are almost never absent in woody Dicotyledons. They have only been recorded as wanting in the genera *Drimys* and *Zygogynum* (*Magnoliaceæ*), and in *Tetracentron* and *Trochodendron* (*Trochodendraceæ*). They are elongated tubes variously termed by older plant anatomists as tracheæ, vasa, fistulæ, tubes, ducts, and vessels. The term tracheæ includes, according to Sanio* and his followers, another class of elements known as tracheids, which can only be distinguished with difficulty from some wood-fibers having bordered pits. It has been retained and employed by some recent authors as a collective term applied to elements having completely closed membranes styled tracheids, as well as to a series of segments having connected cell lumina called vessels. The term "vessels," acording to Rothert,† is used to include both tracheæ and tracheids, but it is thought best to make a clear distinction between vessels and tracheids and consider the term vessels as the equivalent of tracheæ in a work in which the consideration of physiological processes are entirely neglected. De Bary‡ uses tracheæ to designate vessels, tracheids and their intermediate forms. The basis of this classification is purely physiological rather than structural or morphological. Recent investigators such as Radlkofer and Solereder, guided by more practical considerations, based their distinctions on purely morphological characters, and there is now a manifest tendency on the part of many authors to classify these elements according to the characters of their matured framework. The tracheids, which were formerly included in Sanio's tracheal system, have, therefore, been segregated from compound elements composed of a fusion of cells placed end to end, with their partition walls wholly or partially absorbed. It is with this latter group of elements, the history

*Sanio, Bot. Zeitg. 1863, p. 113.

† Rothert. Bullet. de l'Acad. de Cracovie, 34, 1899.

‡ De Bary. Comparative Anatomy of Phanerogams and Ferns, 1884.

of investigations of their development, structure, peculiar modes of sculpture and their classification, that this discussion has to do.

Early Investigations

Numerous treatises dealing with the development, structure, and classification of vessels have been published since the earliest introduction of the microscope into botanical investigations, and yet some comparatively recent discussions on plant anatomy show that there is a confusion in the terminology and classification of these elements. Although von Mohl* and Schacht† have brought out the distinctive characters of vessels and have described in detail the structure and development of their peculiar markings, it was not until the last quarter of the 19th century that the majority of investigators have succeeded in framing a true conception of them, and have been able to name and classify the different forms of vessels found in secondary wood.

It may not be superfluous to dwell briefly upon the history of the early investigations of vessels which have later been so carefully studied by von Mohl, Schacht, Hartig, Strasburger, and others. In order to show the present conception of the structure and classification of vessels, it is thought best to compare briefly those of the earlier plant anatomists.

Malpighi (1628-1694) and Grew (1628-1711) discovered the vessels in wood about the same time (1675). Grew, in his "Anatomie of Plantes" (1682), regarded them as air passages, and from his writings it is clear that there are, as might be expected, many errors in his descriptions of details. Malpighi, in 1674, was the first to observe the vessel segments. Other early observers, especialy Leeuwenhoek (1632-1722), Hedwig (1730-1799), and Hill, a contemporary and countryman of Grew, were familiar with the pitted vessels‡ in plants, but not until the time of Mirbel§ (1776-1854) were they first distinguished from the spiral, annular, and reticulated vessels. Mirbel did not know that vessels are composed of segments, and a discussion of the relationship of vessels with other elements was entirely omitted in his writings. The pits were regarded by Mirbel as swellings projecting from the outside of the vessel walls and which he thought would rupture and form true

*Von Mohl, Linnæa, 1831.

† Schacht's Lehrbuch der anatomy und Physiologie der Gewachse. 1856.

‡ The term *pitted* is applied to vessels having a structure called *getuepfelt* by the German anatomists.

§ Mirbel, Exposition de ma theorie, ets., Paris, 1809, p. 247.

openings. He not only distinguished the cavities in pits, but he also recognized the thin closing membranes. These facts should have been the foundation upon which to build a superstructure by a subsequent plant anatomist—a structure which would have required but little modification in order to conform with the actual facts. This did not happen, however; on the contrary, a number of later investigators gave views which were just so many steps backward in the knowledge of vessels.

During the last decade of the 18th century Sprengel laid the foundation of a great many erroneous opinions. He regarded the pitted vessels, which in other respects he confounded with scalariform vessels, as elements developed from spiral vessels through a peculiar growth of spiral thickenings. He was familiar with the vessel segments, which he determined from a rather decided contraction of vessel walls where they join.

Bernhardi (1774-1850) has the credit of discovering the outer membrane of spiral vessels, but he incorrectly maintains that the scalariform and pitted vessels are developed out of spiral vessels. His views in other respects are those of Sprengel, and he therefore accepted the theory that pits are fragments of collapsed or broken down spiral thickenings. On the whole, Bernhardi contributed materially to the clearing up of the subject by his endeavor to distinguish the different forms of vessels. In 1805 he prepared a short treatise* in which he gives observations that are by far the best since the writings of Malpighi and Grew.

Considerable credit is due to Treviranus (1779-1864) for at least approaching more nearly than any of his predecessors the true solution of the development of vessels. He was the first one to recognize that true vessels consist of a fusion of cells forming a continuous series of segments which he regarded as modified wood fibers. He also suspected that the partition walls between the vessel segments were wholly or partially absorbed, and he classified the vessels according to the following designations: Spiral, striate (gestreifte), scalariform, and pitted. These pitted vessels were formerly known in English terminology as dotted vessels.

In an essay, entitled "Beobachtungen in Betreff einiger streitigen Puncte der Pflanzenphysiologie," Treviranus brought out some very important facts concerning the formation of bordered pits, and he was the first plant anatomist to observe in the wood of sassafras that the parts of vessels bordering pith ray cells possess pits of quite a different character from those on parts of vessels adjacent to other vessels. He considered

*Bernhardi, Beobachtungen ueber Pflanzengefæsse, Erfurt, 1805.

bordered pits as slight perforated elevations with a cavity beneath, but those pits occurring on parts of vessel walls bordering pith ray cells merely as true openings.

Moldenhawer (1766-1827) regarded the vessels as small communicating sacs and, as did Sprengel, Bernhardi and others, maintained that pits originated from broken down spiral and annual thickenings. He demonstrated at some length the existence of thin-closed membranes forming vessels, but like Hedwig, regarded the thickenings as being on the outside of the primary walls. He further determined that, in the wood of linden, the parts of vessel walls bordering upon other vessels have pits, and where they touch wood fibers or pith ray cells that they have spiral markings. Moldenhawer was the first to mention intermediate forms of vessels, and he also maintained that all vessels contain air except in a few instances where they contain sap. Unfortunately in all his investigations he failed to overcome the difficulties of the structure of the bordered pits, notwithstanding the advance he made in isolating cells and vessels for study; this was a decided advantage. He allowed the parts of the plant to decay in water and afterwards crushed them, which is a method much used in modern times.

Hedwig (1730-1799) contended that the spiral thickenings on the inner walls of vessels are hollow because they are colored by absorption, but Bernhardi, Rudolphi and Treviranus maintained that they are solid. Hedwig* and Treviranus in 1789 were the first ones to discover that the spiral bands are attached to the vessel walls, and Moldenhawer, some time later, proved for all time that the cell membranes exist prior to the thickenings.

Meyen (1804-1840) followed Bernhardi in accepting the view that pits are broken down parts of spiral thickenings, and in 1830 gave out a work† in which he considered the annular and reticulated vessels as metamorphosed spiral tubes. He also claimed that these spiral thickenings are the first to be formed and that later they break down into cylindrical or conical bodies, and are afterwards surrounded by a delicate membraneous cell wall.

Link (1767-1851) thought, as did a number of other plant anatomists, that the pits of vessels are the result of broken-down spiral thickenings which he regarded as hollow. He thought that pitted vessels are not present in woody tissue, but intimated that pits are fragments of spiral thickenings that are shorter than scalariform markings. In general,

*Hedwig, De fibræ vegetabilis et animalis ortu, 1789.

†Meyen. Lehrbuch der Phytomie.

Link's account of the sculpture of vessel walls is similar to that of Sprengel and, therefore, an unfortunate one. He distinguished two forms of vessels: namely, porous and pitted vessels, but fails to give a clear distinction between them.

Unger (1800-1870) gave a history* of the development of spiral vessels in which he described them as being formed from a series of cells placed end to end with their partition walls wholly or partly absorbed. He also believed that the reticulated vessels develop from spiral vessels through partial filling in of open places between the spiral bands. Unger, Schleiden, and a number of other investigators maintained that vessels serve only a short time for transporting sap and thereafter contain air.

Schleiden in a work† published in 1846 declared that pit cavities arise from the secretion of air bubbles between the previously blended vessel walls. In this same work he endeavored to explain the origin of annular thickenings in vessels by assuming that in each case two turns of these bands grow together into a ring, while the bands between them are subsequently dissolved. Von Mohl demonstrates, however, that these views are incorrect.

Bernhardi, Moldenhawer, Treviranus, and Meyen gave various opinions regarding the structure of pits until von Mohl (1805-1872) succeeded in solving the problem. He demonstrated for all time that vessels are formed from a continuous row of thin-walled cells that coalesce, but whose cross walls are either perforated by larger or smaller openings or entirely absorbed. The pits, according to his earlier writings, are very thin areas on the vessel walls, and pit cavities consist of hollow spaces between the adjacent vessel walls. Meyen and Schleiden corroborated von Mohl's view regarding the structure of bordered pits. In 1831 von Mohl endeavored to show that the structure of the scalariform and pitted vessels is analogous to that of pitted cells, but in his later writings he agreed with Treviranus that vessels are developed from thin-walled closed cells, that thickening layers are deposited on the inner walls, and that the partition walls are either partly or wholly absorbed. With reference to pitted vessels he clearly demonstrated that their development and structure largely depend upon the nature of the contiguous elements, that the pits are unthickened portions in the vessel walls, and that the pit cavities in vessel walls communicate directly with those in neighboring elements.

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*Unger, Anatomie und Physiologie der Pflanzen, 1855.

† Die Botanik als inductive Wissenschaft.

Von Mohl's Later Investigations

After considering the most weighty conclusions of the earlier investigators, von Mohl in 1842* gave his views regarding the structure of pitted vessels. He first pointed out that vessels in most plants do not possess a uniform structure in all their parts, which he claimed is due to the influence of neighboring elements of another kind. That such a relation exists between pitted vessels and adjacent elements of unlike tissue is shown by the two facts observed by Treviranus and Moldenhawer. Von Mohl pointed out that the conclusion drawn by Moldenhawer in regard to the wood of linden is true in respect to a number of other plants, and that the pith rays have a similar influence upon the structure of vessels in all woody plants that have vessels, in so far as the part of a veessel adjacent to a pith ray has irregular simple pits. Von Mohl demonstrated that simple pits are found on parts of vessel walls where the neighboring elements are horizontal, but where they are parallel the pits are bordered. He further stated that pits on walls common to two unlike elements always coincide with one another, and he derived from these and similar facts that the organization of the secondary thickening layers in one kind of elements stands in intimate relation with that of similar layers in adjacent elements of another order.

That such an inference could be drawn from the structure of pitted vessels was questioned by Meyen, who thought that the facts upon which von Mohl based his conclusions are analogous to characters present in the wood of conifers that have tracheids provided with pits only on the radial and not on the tangential walls. It was this objection, however, that von Mohl considered as the best proof of his theory, because in conifers only that portion of a tracheid adjacent to a similar element possesses bordered pits. In junipers and in most pines the parts of walls of tracheids touching pith rays possess simple pits, which coincide exactly with those in the pith ray cells. An objection was raised to this theory by some of von Mohl's contemporaries on the ground that vessels in some plants show uniform pits, both with respect to size and form, whether the vessels are adjacent to similar or dissimilar elements. Von Mohl made the fact clear, however, that the influence which elements sometimes exert upon the structure of adjacent elements is not in all cases so strongly marked as to interfere with the development of characteristic pits. In some plants or parts of plants the power within the elements themselves to develop uniform pits is stronger than the influence of

* Von Mohl, Ueber den Bau der getuepfelten Gefæsse. Linnæa. 1842.

neighboring elements, and for this reason the characteristic structure of pitted vessels attains more or less perfect development in all its parts. The few exceptions which may be noted do not prove that no such influences are at work.

Von Mohl gave further evidence of this influence by investigating the elements surrounding the vessels. He first pointed out that there are only relatively few dicotyledonous plants having vessels of uniform structure. Only such vessels can come into consideration as are surrounded by dissimilar elements, and those that are contiguous only with wood fibers or only with pith ray cells must be excluded, since such vessels always have walls of uniform structure. Apart from such individual vessels he found in *Eloeodendron croceum* DC. and *Viburnum opulus* L. groups of modified vessels showing this influence expressed very clearly.

Von Mohl's Conclusions

After a number of years of uninterrupted application to plant anatomy von Mohl collated his principal observations in connection with pitted vessels as follows:

1. The characteristic structure of vessels is most highly developed in those plants vessel walls of which have uniform markings whether they are adjacent to other vessels or to elements of another order. All the vessels of *Elæagnus latifolia* L., *Clematis vitalba* L. and *Broussonetia papyrifera* Vent. have bordered pits irrespective of the kind of neighboring elements.

2. There is a second type of vessels having some parts of their walls adjacent to wood fibers with bordered pits. The influence, however, which the nonequivalent neighboring elements have on the vessels is clearly expressed by the fact that the pits on the adjacent vessel walls are less numerous. Such structures are found in *Bixa orellana* L., *Albizzia lophantha* Benth. and *Sophora japonica* L.

3. The most marked dependency of structure in vessel walls having numerous bordered pits is shown in places where vessels are adjacent to wood fibers. In such parts of vessel walls the pits are small, few, or sometimes wanting. Vessels that border pith rays have simple pits in *Sambucus alba* Rafin., *Aralia spinosa* L., *Corylus avellana* L., *Populus alba* L., *Alnus incana* Medic., *Platanus occidentalis* L., *Pyrus malus* L., and *Gymnocladus dioicus* (Linn.) Koch.

4. Parenchyma cells influence the structure of contiguous vessel walls more strikingly than wood fibers. The pits on vessel walls that touch pith ray cells are usually simple, as can be observed in *Cassytha glabella* R. Br., *Eriodendron anfractuosum* DC., and *Hernandis ovigera* L.

5. Another modification of structure having a very characteristic appearance is that type known as scalariform. The pits are slit-like, and extend across the entire width of the vessel, while those in adjacent cells of another order have round, simple pits. This form is beautifully developed in *Chilianthus oleaceus* Burch. and *Gonolobus obtusifolius* Schult.

Von Mohl states that the majority of pitted vessels can be classified under the above forms, but that there is another kind showing spiral thickenings between the rows of pits. These are to pitted vessels what the spiral tracheids of Taxus are to the tracheids in the rest of the Coniferæ. He observed, however, that vessels can not be classified on the basis of resemblances and differences of their pits, but he found more reliable characters for grouping them. In many woods both large and small vessels are present, especially in the inner part of concentric zones where they usually occur in groups. The small vessels in transverse section approach wood fibers in size and may be termed small vessels.

Classification of Vessels

Von Mohl attempted to classify vessels acording to the number and character of pits. This scheme of classifying vessels was unsatisfactory, however, and could not be employed because the characters upon which the scheme was based were not sufficiently constant. The classification is as follows:

1. All vessels having bordered pits; the large vessels with smooth walls and the small ones with spiral thickenings running between horizontal rows of pits, as shown in *Morus alba* L., *Ulmus campestris* L., and *Clematis vitalba* L.

2. All vessels having their pits close together and between the rows of such pits very narrow fibrous thickenings. This is shown in *Hakea oleifolia* R. Br.

3. Large vessels having pits; small vessels having the pits wanting, as in *Daphne mezereum* L., *Passerina filiformis* L., *Bupleurum gibraltaricum* Lam., and *Cytisus candicans* Lam.

4. Vessels adjacent to other vessels having numerous pits, and vessels contiguous with wood fibers having very few pits, or entirely wanting. All vessel walls are marked by fibrous thickenings in *Myrsine pentandra* R. Br., *Tilia cordata* Mill., *Æsculus hippocastanium* L., *Acer pseudoplatanus* L., *Cornus alba* L., *Ilex aquifolium* L., *Cratægus oxyacantha* L., *Prunus padus* L., and *Virginiana* L.

From all these observations von Mohl finally concluded that uniformity in the structure of vessel walls relatively seldom exists. He also

stated that the only constant character possessed by certain pitted vessels (small vessels excepted) which enable their differentiation from other vessels is the presence of bordered pits, at least on walls adjacent to other vessels. The question arose as to whether all the different forms of vessels above referred to should be classed among pitted vessels, or whether only those vessels having bordered pits on all sides should be called pitted vessels. This would relegate all others among the mixed vessels. Von Mohl endeavored to answer this question from his own observations, and he succeeded after a number of years of most painstaking examinations of the most suitable objects.

According to von Mohl, all vessels with only bordered pits show in their structure a common character which definitely distinguishes them from those having additional characters. Had he classified among mixed vessels all those vessels showing minor differences he would have been less likely to give a definite idea regarding the different groups. The term mixed vessels is commonly considered to include those in which different segments strongly overlap and show widely different structures, or such as have markings which differ somewhat from the reticulated, annular or spiral type which he distinguished. If all vessels showing different structures on opposite walls are considered as belonging to mixed vessels, two different conditions are compared which are not possessed in common, in so far that one form of marking is arranged and modified according to neighboring vascular tissue, while the other is determined by horizontal elements bordering it. The desirability of adopting a name for all those slight modifications of vessels seemed entirely superfluous to von Mohl, and on this point he was ably supported by the best plant anatomists of his time. Unfortunately several more recent investigators gave a terminology which, if adopted, would lead into a labyrinth of confusion. The presence of few or many small pits on vessel walls could not be accepted as distinguishing characters, since size and number are relative terms and do not form a reliable basis for classification, and therefore von Mohl sought more constant features. Keiser* believed that aside from the pits the partition wall between the vessel segments would furnish trustworthy characters, but this was found entirely unreliable by von Mohl when he tried to base his classification of vessels on the structure of pits and other markings.

Von Mohl investigated the structure of the pits in *Cassytha glabella* R. Br., since the large size of the pits rendered their study comparatively easy. It would have been more difficult to learn this structure from the

*Grundzuege de Anatomis der Pflanzen, 1815.

vessels of certain other plants, and yet in such plants as *Laurus nobilis* L., *Sassafras sassafras* Karst., *Aleurites triloba* Forst. Car. Gen. 112, *Albizzia lophantha* Benth., it would have been possible to observe these characters equally as well. Von Mohl thus determined that the borders of pits are mere cavities lying between the two contiguous vessel walls, and that an individual pit consists of two converging canals that lead from the vessel lumina to the pit cavity. He observed the structure of pits more carefully than any other investigator, but his reference to the closing membrane shows that as early as 1842 he was not entirely clear as to its real character and functions. He also discovered that in many plants the canals as well as the borders are somewhat elongated in a direction perpendicular to the axis of the vessel. The pit canal is not an elliptical tube of uniform width, but has a rather complicated form. The outer end of the canal is pressed together in the direction of the long axis of the vessel, but the inner end is compressed in the direction of the diameter of the vessel. The inner opening of the pit canal is often slit-like, while the outer opening of the cavity which is separated from the one in the adjoining vessels by the primary cell membrane presents a circular appearance which sometimes approaches an ellipse. By looking perpendicularly through the inner opening of the pit canal when the walls of the canals gradually widen toward the outer edge of the vessel, two concentric rings are observed. The form of the pit depends upon whether the view is taken from a cross or long section of the vessel wall; in the former the pit canal is regular or conic, while in the latter it may be circular or elliptical.

The enlargement toward the inner end of the canal is not clearly shown in vessels of some dicotyledons so that the inner opening is considerably shorter than the border of the pit, as, for instance, in *Cassytha glabella* R. Br., *Elæodendron croceum* DC., *Bixa orellana* L., *Albizzia lophantha* Benth., *Sophora japonica* L., *Salix alba* L., and *Aralia spinosa* L. In other plants the inner openings of pits are slit-like, and are longer than the borders. This can be seen in *Sassafras sassafras* Karst., *Aleurites triloba* Forst. Char. Gen. 112, *Clematis vitalba* L., *Cornus alba* L., *Morus alba* L., *Gymnocladus dioicus* (Linn.) Koch., and *Elæagnus latifolia* L. In many cases the slit-like openings are arranged in rows forming long continuous grooves on the inner walls into which lead from two to six more pit canals, often giving the appearance of scalariform markings as in *Chilanthus oleaceus* Burch. Each slit is surrounded by a border which is wider than the slit itself, and which can be easily seen in longitudinal section. Von Mohl stated that it is possible to separate, upon the first glance, the ordinary scalariform markings from this forma-

tion by the presence of these longitudinal cavities, since the former have no borders.

Aside from pits having a border, another modification is found that has the border wanting. Such pits occur in parts of vessels adjacent to pith ray cells. They may occur, however, as von Mohl states, on vessel walls not contiguous to pith ray cells, as in *Cassytha glabella* R. Br., *Elæodendron croceum* DC., *Hernandia ovigera* L., and *Chilianthus oleaceus* Burch. Pits of this character usually have wider openings than the pit cavities and are for the most part oval. By close observation it is possible to see that they are bounded by two concentric lines so that in many cases, especially in *Aleurites triloba* Forst. Char. Gen. 112, they appear to have a very narrow border. The double boundary lines of pits result from a widening of the inner or outer portion of the canals. By viewing a bordered pit on the flat surface it is possible to see the inner mouth of the canal as a small opening. The pit canals in the vessel walls occasionally pass through in an oblique direction and the boundary lines of the inner and outer end of the canal cross into each other, as is frequently seen in *Opuntia brasiliensis* Haw.

Von Mohl confined himself to a few remarks regarding the cross walls between vessel segments. In his earlier writings he shows that they are not always absorbed until after advanced development, when they are always perforated by true openings. The perforations are of two kinds. Either a great portion of the original cross wall remains, or there is developed in the middle of it a round opening the diameter of which is one-half or one-third the diameter of the vessel. The cross walls are most generally broken through by a number of horizontal slits one over another and are known as scalariform perforations. Von Mohl has observed scalariform perforations only in strongly oblique cross walls, as they are found in *Betula alba* L., *Fagus sylvatica* L., *Corylus avellana* L., *Alnus incana* Medic., *Platanus occidentalis* L., *Viburnum opulus* L., *Ilex aquifolium* L. The other form is present only in horizontal cross walls, but these do not always show the same structure even within the same plant. Some may have scalariform perforations, while others may be entirely absorbed.

Von Mohl observed pitted vessels during their entire course of development, and saw that they appeared at first like long rows of uniform, thin-walled and perfectly closed nucleated cells. A little later he saw them develop slight fibrous thickenings on the side walls bordering other vessels. Following the development still further, he was able to see that the portions between the network of thickenings corresponded later to pits. He also observed that during the entire period of development the vessel

lumina are filled with sap and not with air, and that spaces between the vessels also contain sap. Immediately after the element has taken final shape the pits come into evidence in the form of faint light circles, and then develop very rapidly.

That the secondary layers of individual vessels do not correspond exactly in their structure is clear from what has already been said concerning the form of pits. The depressions in these layers are sometimes larger and more elongated toward the inner opening of the pit canals. In *Elæodendron croceum* DC., there is a widening of the pit canals toward the vessel lumen, which is also shown very clearly in *Cassytha glabella* R. Br., and *Sassafras sassafras* Krast. These inner openings are slit-like and are not only longer than the borders of the pits are wide, but the slits freely communicate with each other and connect from a few to many pits. These inner lining layers are thus divided in an incomplete manner by the pit openings which do not always coincide with the long axes of the borders beneath or with the slits in adjacent vessels. The fibrous thickenings in the tracheids of *Taxus* forming a part of the innermost layers are often arranged at right angles to the long axis of the pits, but the most marked difference between the outer and inner lining layers are seen in the vessel walls of *Tilia* and *Daphne*.

From 1830 to 1850 von Mohl gave numerous expositions on the matured framework of cell membranes. All his researches are entirely free from fanciful theories and his conclusions are based on purely visible structures. He possessed a technical knowledge of the microscope and could polish and set lenses equal to the best of his time. With this advantage at hand and his power of keen observation and knowledge of what others before him had accomplished in plant anatomy, he was able not only to refute a great many ill-considered theories regarding the structure of vessel walls, but to bring to light and establish a mass of facts. The numerous theories regarding the thickenings of cell walls which were advanced by his contemporaries and investigators before his time were not accepted by him at once, but he brought together a mass of facts which he used to prove or disprove beyond doubt such conclusions. The results of his scientific labors were published from time to time in the shape of monographs which were confined solely to important questions of the day. He invariably pointed out how others sought to explain the origin of certain structures in the framework of plants, and if their expositions were found wanting in scientific accuracy he refuted them by giving established facts which conclusively disproved their statements. His writings give the reader the impression of thoroughness, and his observations on the structure of the secondary membranes

impress one with their convincing sense of correctness. His classification of structures, as given in his later writings, are still followed by the ablest plant anatomists.

He classified the different vessels according to the modification of the structure of their secondary thickening layers into spiral, annular, reticulated and pitted or dotted vessels. Briefly, he considered them as follows:

Spiral vessels are most common in herbaceous plants, but they sometimes occur in all plants possessing vessels. In woody plants they are generally found in the vascular bundles next to the pith. The secondary membranes of spiral vessels are divided into one or more parallel fibrous thickenings, which, as a rule, terminate in an annular arrangement at the upper and lower ends of the segments. If vessels are developed in tissue which has already completed its growth in length, the turns of the spiral thickening lie close together, but if they elongate after the thickening is completed, the turns are drawn farther apart by the stretching which the vessels undergo. Consequently, very loosely-wound spirals are found in the vessels of bundles next to the pith, while those lying near the bark have close turns. The direction of the spiral is generally to the right—that is, in a botanical sense, in the manner of a left-handed screw. The spirals of two contiguous vessels, therefore, cross upon the two coherent walls.

Annular vessels were regarded by von Mohl as slight modifications of the spiral kind. These fibrous thickenings are arranged in a transverse direction on the vessel wall, crossing the longitudinal axis of the vessel at right angles. Occasionally this kind of structure alternatees with spiral bands in the same or adjacent vessels. This he regarded as an intermediate form between the right and left wound spiral markings. That the annular vessels form a slight modification of spiral vessels is shown, for example, in cases where a series of vessels with spiral thickenings are followed by a series of vessels with annular thickenings, or where spiral and annular markings alternate without any definite rule, even within the same vessel.

Reticulated vessels occur in manifold modifications among vascular Cryptogams, and in outer parts of the vascular bundles of Monocotyledons. When two adjacent vessel walls are covered with pits, the much elongated pit cavities of which extend across the entire width of the side walls, but do not reach beyond the area adjacent to the neighboring vessel, the vessels are said to have scalariform markings. When the walls of vessels are in contact with elements of another order and the pits ex-

hibit an elliptical or rounded form, and are distributed irregularly, or arranged spirally, the vessels are said to have reticulated markings. Frequently the same vessel exhibits both modifications of structure.

Pitted vessels chiefly occur in secondary wood of Dicotyledons and exhibit numerous bordered pits on sides of walls adjacent to other vessels. Walls of vessels bordering on wood fibers or parenchyma cells have simple pits, or have them entirely wanting.

EXPERIMENTS IN THE PRESERVATION OF FOREST SEEDS

DR. E. ZEDERBAUER*

[TRANSLATED FROM THE GERMAN BY MAX H. FOERSTER]

The method of preserving acorns and beech-nuts through the winter by stratification in sand was already known in the 16th century. Artificial reforestation, which began in Germany in the 14th century, resulted in a demand for methods of preserving seeds. Most of these have been forgotten, like many other experiences of practical men; on the other hand many of them have been handed down by tradition. In "Grundsätze der Forstökonomie," 1757, p. 486, W. G. Moser gives a detailed account of the preservation of coniferous and non-coniferous seed in mixture with sand and sawdust to prevent desiccation. He mentions pits as a good method for preserving acorns. These and other methods are frequently described in forest literature. I should like to call attention to the "Experiments on the Preservation of Acorns" by A. Cieslar (Centralblatt für das gesamte Forstwesen, 1896) and to the discussion just published by Haack: "Pine-seed Preservation for Several Years Without Decrease in Germination" (Zeitschrift für Forst- und Jagdwesen, July, 1909), without however, disregarding other papers treating on this same subject.

Nearly all experiments agree in the selection of certain localities, cellars, garrets, etc., for storage rooms. The difference between the rooms designated above shows different results in different localities and in one and the same house and under apparently the same conditions.

The question which leads to the experiments discussed here and those to be published later on was as follows: What are the factors governing the natural preservation of seed up to the time of germination and what life processes are carried on in the seed during its dormant stage? The answer mainly to the second part of the question and its practical application is fundamental and decisive for rational preservation.

The seeds and fruits of our forest trees mature in summer and fall, those of a small number of species, such as willows, elms, birch and poplar maturing in May and June. The falling of seed and fruit continues throughout the year. By March and April the larch and fir have distributed the last of their seed of the preceding year and in May willow and poplar begin to disseminate their just matured seed.

*Versuche über Aufbewahrung von Waldsämereien. (In Centralblatt für das gesamte Forstwesen, March, 1910, v. 36; 116-21.)

The seed of most of our forest trees falls in autumn after the seeds mature, from September to December; only a few species as ash, spruce, larch, white and black fir and in most cases the moutain pine (Pinus montana) and the locusts retain fruit and seed on the tree till spring.

The seed and fruit of oak, chestnut, beech, hornbeam, maple, basswood, cherry, juglans, alder, fir, cembra pine, and juniper fall at maturity and lie on the ground over winter exposed to moisture and low temperatures; the seed of spruce, larch, black and white fir and mountain fir remain in the cones over winter protected from too much moisture but also exposed to low temperatures. The same is more or less true of the fruits of ash and locust.

"Which life processes are active in the dormant seed?"

Seeds and fruits must be regarded as living organisms which breathe and transpire. The process of breathing is a destructive assimilation. From the organic material destroyed by it, carbon dioxide and water result.

Respiration is influenced chiefly by temperature. It increases with the temperature up to a certain optimum and then decreases again.

Transpiration is also under the influence of temperature and not inconsiderably, as can be readily seen, of the moisture content of the atmosphere. It is known for a fact that a low temperature lowers respiration and transpiration, causing a decrease in destructive assimilation. This fact is of the utmost importance for the practical storage of seed.

In the natural form of storage low temperatures, although not constant, but varying around 0°C., as well as a high degree of soil and atmospheric moisture are dominant. Nature, however, provides abundantly, so that in spite of an enormous loss through rodents and unfavorable germinating bed there is always enough seed left for regeneration. The extravagance of nature is, however, prohibitive in artificial seeding. If the seed are to be stored over winter till the appearance of conditions favorable to germination, the first consideration must be an advantageous method of storage which conforms in its chief features to the method pursued by nature. These circumstances alone, together with a knowledge of the life activity of the seed, can guide us towards the most favorable method of storage on a small as well as a large scale. It was thus of prime importance to examine the two factors, temperature and moisture, as to their effect on seeds. In doing this the first series of experiments was conducted so as to conform as closely as possible to the natural conditions; of course a series of experiments under exactly the opposite conditions was not omitted. Refrigerators or ice-cellars, which Haack also mentions in his recently published article, seem to be the most efficient and favorable storage place for forest seeds on a large scale.

Experiments

Table I shows the place of storage and the most important external factors of influence during the time of storage.

TABLE I.

No. of Series.	Influencing Factors during Period of Storage.	Description of Storage Room.
1*a*.	Temperatures above and below Zero (about +10° to —10°). Atmospheric Moisture quite high.	Wooden shack, open on one side only. Seeds were suspended in a cloth sack.
1*b*.	Temperatures above and below Zero (about +10° to —10°). Atmospheric Moisture quite high.	Very airy loft. Seeds suspended in small cloth sacks.
2*a*.	Temperatures above Zero only (about +4° to 10°). Low atmospheric Moisture.	Cellar. Seeds suspended in small cloth sacks.
2*b*.	Temperatures above Zero (about 8° to 12°). Low atmospheric Moisture.	Unheated room.
2*c*.	Temperatures above Zero (10° to 20°). Very low atmospheric Moisture (dry).	Heated room.
3*a*.	Temperatures above and below Zero (about – 10° to +10°). Soil Moisture.	Sowed in open seed bed.
3*b*.	Temperatures above and below Zero (about – 10° to +10°). Soil Moisture.	In a clay pot mixed with sand sunk in the ground and covered with moss.
3*c*.	Temperatures above Zero (about – 5° to +10°). Soil Moisture (slight).	Loft; mixed in a pot with continually moist sand.
4*a*.	Temperatures above Zero (about 4° to 10°). Soil Moisture (slight).	Cellar; mixed in a pot with continually moist sand.
4*b*.	Temperatures above Zero (about 8° to 12°). Soil Moisture (slight).	Unheated room; mixed in a pot with continually moist sand.

All seeds and fruits which had not been sown in the fall were sown in seed beds in drills in the spring to test their per cent of germination. To obtain comparative results seeds of the same origin were used for the different species and equal amounts for each series of experiments.

Table II gives a clear conspectus of the results secured by sowing the different samples.

TABLE II.

Species.	Method of Storage. No. of Seed.	Amount of Seed Sown.	Experiment Begun.	Date of Sowing.	No. of Seeds Germinated.
		Grams.			
Abies alba.......	1*b*	100	7. XII. 1905	2. V. 1906	104
	2*b*	100	7. XII. 1905	2. V. 1906	67
	3*a*	100	7. XII. 1905	7. XII. 1905	128
	2*b*	75	11. XII. 1906	22. IV. 1907	10
	3*a*	75	11. XII. 1906	11. XII. 1906	86
Picea excelsa	1*b*	75	7. XII. 1905	2. V. 1906	615
	2*b*	75	7. XII. 1905	2. V. 1906	450
	3*a*	75	7. XII. 1905	7. XII. 1905	105
	1*a*	40	14. XII. 1906	2. V. 1907	180
	2*b*	40	7. XI. 1906	2. V. 1907	70
	2*c*	40	7. XI. 1906	2. V. 1907	100
	3*a*	40	7. XI. 1906	7. XI. 1906	91
Larix europea....	1*a*	10	11. XII. 1906	2. V. 1907	63
	1*b*	10	11. XII. 1906	2. V. 1907	95
	2*b*	10	11. XII. 1906	2. V. 1907	88
	2*c*	10	11. XII. 1906	2. V. 1907	75
	3*a*	10	11. XII. 1906	11. XII. 1906	10
Pinus sylvestris .	1*a*	30	11. XII. 1906	2. V. 1907	640
	1*b*	30	11. XII. 1906	2. V. 1907	653
	2*a*	30	11. XII. 1906	2. V. 1907	960
	2*c*	30	11. XII. 1906	2. V. 1907	950
	3*a*	30	11. XII. 1906	11. XII. 1906	21
Pinus peuke.....	1*a*	400	12. XII. 1906	23. IV. 1907	9
	2*b*	400	12. XII. 1906	23. IV. 1907	6
	3*b*	400	12. XII. 1906	23. IV. 1907	27
	4*b*	400	12. XII. 1906	23. IV. 1907	2
Fagus sylvatica..	1*a*	150	4. XII. 1906	20. IV. 1907	28
	1*b*	150	4. XII. 1906	20. IV. 1907	12
	2*a*	150	4. XII. 1906	20. IV. 1907	24
	2*b*	150	4. XII. 1906	20. IV. 1907	44
	2*c*	150	4. XII. 1906	20. IV. 1907	45
	3*a*	150	4. XII. 1906	4. XII. 1906	Destroyed by mice.
	3*b*	150	4. XII. 1906	20. IV. 1907	0
	3*c*	150	4. XII. 1906	20. IV. 1907	46
	4*a*	150	4. XII. 1906	20 IV. 1907	36
	4*b*	150	4. XII. 1906	20. IV. 1907	81

TABLE II—*Continued.*

Species.	Method of Storage. No. of Seed.	Amount of Seed Sown.	Experiment Begun.	Date of Sowing.	No. of Seeds Germinated.
		Grams.			
Quercus cerris...	1*a*	100	30. X. 1906	4. IV. 1907	0
	2*a*	100	30. X. 1906	4. IV. 1907	3
	2*b*	100	30. X. 1906	4. IV. 1907	0
	2*c*	100	30. X. 1906	4. IV. 1907	0
	3*a*	100	30. X. 1906	9. XI. 1906	25
	3*c*	100	30. X. 1906	4. IV. 1907	0
	4*a*	100	30. X. 1906	4. IV. 1907	87 } Germinated
	4*b*	100	30. X. 1906	4. IV. 1907	64 } in the sand.
Juglans nigra....	1*a*	100	7. XI. 1906	3. IV. 1907	18
	1*b*	100	7. XI. 1906	3. IV. 1907	26
	2*a*	100	7. XI. 1906	3. IV. 1907	37
	2*b*	100	7. XI. 1906	3. IV. 1907	19
	2*c*	100	7. XI. 1906	3. IV. 1907	13
	3*a*	100	7. XI. 1906	9. XI. 1906	72
	3*b*	100	7. XI. 1906	3. IV. 1907	70
	4*a*	100	7. XI. 1906	3. IV. 1907	60
	4*b*	100	7. XI. 1906	3. IV. 1907	14
Aesculus hippocastanum.	1*a*	100	29. X. 1906	3. IV. 1907	0
	1*b*	100	29. X. 1906	3. IV. 1907	0
	2*a*	100	29. X. 1906	3. IV. 1907	29
	2*b*	100	29. X. 1906	3. IV. 1707	0
	2*c*	100	29. X. 1906	3. IV. 1907	0
	3*a*	100	29. X. 1906	9. XI. 1906	90
	3*b*	100	29. X. 1906	3. IV. 1907	79
	3*c*	100	29. X. 1906	3. IV. 1907	10
	4*a*	100	29. X. 1906	3. IV. 1907	88
	4*b*	100	29. X. 1906	3. IV. 1907	77

Conifers

Of the conifers Abies alba and Pinus peuke cast their seed in the fall. During the winter they remain on the ground partially covered with needles or leaves. They are exposed to low temperatures (frost) and soil moisture or else under a cover of snow. Breathing as well as transpiration are greatly reduced under these external factors. Storage methods which closely approach the manner in which the seeds naturally pass the winter and expose the seed to similar factors as those under X 3*a* and 3*b* attain the best results. A low atmospheric moisture content and temperatures of above zero only, show poor results.

Picea excelsa, Pinus sylvestris and Larix europea do not cast their seeds till late winter or spring. Soil moisture, which achieved the best results with Abies alba and Pinus peuke, influences these species in the op-

posite direction (X 3*a*). Low temperatures have a favorable effect on the seeds of these three species, but not in combination with soil moisture. Atmospheric moisture, however, in higher or lower degrees, combined with low temperatures, favors preservation of the germinative power, although the average room temperature did not decrease the germinative power of Pinus sylvestris seed.

Hardwoods

Only hardwoods which cast their seeds or fruit in fall were considered. It must be observed, that seeds rich in endosperm and with thin seed-coats are very sensitive to a lack of moisture (Nr. 2*b*, 2*c*, 3*c*), i. e., Quercus cerris, Aesculus hippocastanum. Thick-shelled seeds, like those of Juglans nigra, will keep even under such conditions, however, with a great loss of germinative power. Fagus silvatica showed inconceivable results, presumably due to some disturbance during the experiment. This experiment will be repeated. Referring to the results obtained by A. Cieslar in storing acorns, it is apparent that low temperatures and a high degree of moisture are the best preservers of germinative capacity, while the temperatures and moisture conditions in a dry cellar or a heated room are quite unfavorable to germination.

Low temperatures and a high degree of moisture are secured if the acorns are—

1. Laid on the ground and covered with moss.
2. Mixed with and covered with sand on the ground.
3. In earth pits, mixed with sand or soil.
4. In well-water.
5. On the ground covered with a dry litter of needles.

Storage under exclusion of the air has a favorable effect on the vitality and germination of coniferous seed, such as black and white fir and spruce.

In his article published in 1909, Haack has proven fully the favorable influence on white fir seed of low temperatures under exclusion of the air. The reaction corresponds to the fact that respiration and transpiration of seed are greatly decreased by low temperatures and prevention of an exchange of air, which favors desiccation. Storage in an air-tight cellar has achieved the best results, according to Haack.

Low temperatures and a high degree of atmospheric moisture or soil moisture are favorable factors in natural and artificial seed preservation, and should be considered first on account of their retarding influence on respiration and transpiration.

EUCALYPTUS POSSIBILITIES ON THE CORONADO NATIONAL FOREST

R. L. ROGERS

(*Contributed*)

The success which has accompanied eucalyptus culture in certain parts of California has stimulated public interest to such an extent that at one time or another hopes have been expressed by the most optimistic that these trees could be successfully grown in many different parts of the United States. To those who have given the subject serious study it has been apparent the limits within which the large majority of the species may be propagated are pretty clearly marked by temperature lines. Yet among those who through individual study are best equipped to treat of eucalyptus culture in this country, there have been no definite opinions promulgated as to the limits of the extension of the genus. The late Prof. A. J. McClatchie (Bulletin No. 35, Forest Service, "Eucalyptus Cultivated in the United States,") has so far given the subject the most comprehensive treatment, and it is the aim of this discussion to give thorough consideration to those portions of his bulletin which have local application.

The question of the possibility of utilizing eucalyptus as a forest cover on certain of the National Forests in Arizona has been repeatedly raised. While the data at present on hand are entirely inadequate to afford a comprehensive discussion of this subject, it is the aim of this paper to discuss the possibilities of eucalyptus culture on a specific typical tract, namely, the Santa Catalina Range of the Coronado National Forest. Pertinent questions of immediate importance are these:

1. With our present knowledge of the subject, are the conditions adapted to the employment of eucalyptus for forestation purposes?
2. To what extent is experimental planting warranted?
3. What experiments should be inaugurated?

The aim will be to answer these questions. Eucalyptus culture, and particularly the subject of site requirements, has been so generally treated that this discussion will be confined as closely as possible to the technicalities of the region under consideration.

The Santa Catalina Mountains, which here include the Rincon Mountains, consist largely of uplifted and folded granite and gneiss, forming

a range approximately 35 miles long and 10 to 25 miles in width with a general N. W.-S. E. trend. Quartzite and limestone occur on the north and east slopes. Approximately two-thirds of the drainage goes to the south and the remaining one-third to the north and east by way of narrow bottomed, deep cut canyons with precipitous sides. Rough, irregular side ridges are characteristic. The elevation along the exterior forest boundaries of the Santa Catalinas averages for the most part between 3500 and 4000 feet. In the vicinity of Sabino Canyon it falls to 3000 feet. Mt. Lemon, the highest peak, reaches 9150 feet.

Coniferous growth prevails above 6000 feet, while the forest growth below this elevation consists of a thin cover of growth characteristic of the lower mountain elevations, including oaks, cacti, palo verde and acacias. In this discussion we are not concerned with the tract above the 5000-foot contour. The area thus involved includes a strip extending in from the exterior boundaries from one to three miles. This portion of the foothill type is for the most part made up of barren, gravelly slopes, and round-topped hills, comparatively gentle and regular in contour, and broken at intervals by canyon mouths.

The soils have geen derived from the disintegration of granite rocks. Outcrops containing 50 per cent or more of volcanic rocks occur near the mountains. To the formation composing the foothills the term "Catalina Wash" has been applied. In the washes small patches of broken and tilted deposits of soft sandstones, shales and conglomerates are found. With the exception of places here and there in the narrow canyon bottoms, there are no indications of ground water supply capable of practicable development. The soils are deficient in humus and are probably lacking in organic matter and nitrogen.

No attempt will be made to enter into a discussion of the temperature conditions in detail in this paper, since, as will be evidenced later, the temperatures, although intimately related to the moisture conditions, are, so far as growth is concerned, of subordinate importance in this particular case. J. J. Thornber has concisely stated in Bulletin 68 of the University of Arizona Agricultural Experiment Station: "Eucalypts to grow in the warmer parts of Arizona must be able to endure maximum temperatures from 108° to 120° F. with low humidity and intense sunlight, and also survive 10 to 20 degrees of frost in winter." These conditions apply to the case at hand.*

*Dr. D. T. MacDougal has found that there is a total of about 12 hours in the year during which plants at the Desert Laboratory may be subject to freezing temperatures.

The average annual rainfall for the period 1868-1890 kept at Fort Lowell, six miles northeast of Tucson and five miles from the foothills, at an elevation of 2,435 feet, is 12.66 inches, while an average of 11.57 inches was obtained at Tucson, elevation 2,400 feet, by the University of Arizona for the period 1876-1909. Combined records kept by the Forest Service, the Desert Botanical Laboratory and the University of Arizona indicate that the summer rainfall at the high elevations in the Catalinas is about 2.6 times the rainfall in the valley. The precipitation on the particular area under consideration varies between the rainfall in the valley and on the mountains, probably more nearly approximating the rainfall at Fort Lowell. However the character of the rains and the rainy seasons are of more concern here than the average annual rainfall.

The rains occur in two distinct seasons of the year and are known as the winter rains and the summer rains. The former occur from November to March, inclusive, the latter during July, August and September. In April, May, June and October, rains are unusual though not unknown. In general character the two rainy seasons are entirely dissimilar. Winter rains are exceedingly irregular in their monthly distribution. Most of the precipitation may occur in early winter or it may come in February and March, or it may be quite evenly distributed. As a rule the rainfall is slow and steady. Summer rains on the other hand vary less from year to year. Beginning about July 10, the summer showers are of frequent occurrence for a period of about eight weeks. They are not of wide extent, but are very local in character, the wetted area often not exceeding a half mile in width. The duration of the storms is short but the precipitation is very often torrential.

Small as the annual totals are, yet their importance is likely to be overestimated by one not accustomed to arid conditions. High temperature and cloudless skies create an intensely rapid evaporation and after a rain of ordinary volume the ground dries out with incredible rapidity. The annual evaporation as measured by the Weather Bureau standards is eight times the rainfall, and it is to be noted that the excess of evaporation is greatest during the months when soil moisture is most effective in the growth of crops. Drought years are of frequent occurrence. In the rainfall record kept by the University of Arizona at Tucson for the period 1876-1909, one-sixth of the annual totals are less than eight inches. It is to be particularly noted that years of low rainfall often succeed one another. The following table shows the average distribution of rainfall by months for the periods previously mentioned.

*Inches by Months.**

Place.	Period.	J.	F.	M.	A.	M.	Jn.	Jl.	A.	S.	O.	N.	D.
Ft. Lowell	'68–'90	1.14	1.15	0.83	0.28	0.05	0.30	2.68	2.94	1.36	0.46	0.52	0.95
Tucson	'76–'09	0.80	0.96	0.81	0.32	0.14	0.25	2.40	2.46	1.00	0.60	0.76	1.09

Annual.

Fort Lowell	12.66.
Tucson	11.57.

No record has been found of the planting of eucalyptus in this vicinity upon sites comparable to the tract under discussion. The following species have been noted by the writer planted for ornamental purposes in Tucson within the past few years: eucalyptus rostrata, tereticornis, crebra, polyanthema, and rudis. The largest trees are about 20 to 25 feet high and all were killed back more or less severely by frost last winter. The results obtained at the University of Arizona Experiment Station tend to show that rudis and rostrata withstand the conditions best, in the order named. All of the trees noted have received irrigation. It is interesting to note that the same conclusions have been obtained in the experimental plantations made on the Tonto National Forest near Roosevelt, where the following species have been slightly tested: tereticornis, viminalis, rudis, and rostrata. At the Monthan Bros.' ranch, 12 miles east of Tucson, the following species were planted four years ago along an irrigation ditch and cut last spring for fence posts: rostrata, tereticornis, polyanthema, crebra, and rudis. The trees developed well but were somewhat killed back last winter by a temperature of 16° F. Mr. Monthan believes rudis and tereticornis best adapted to the conditions on his ranch.

Since in all the examples just cited the trees received irrigation, the results obtained are applicable to forest planting on the sites above described only to a very limited degree. Irrigation on the forest tract is out of the question. The results do indicate, however, that in so far as temperatures are concerned, a few varieties such as rudis and rostrata may be grown with some degree of success subject of course always to a certain amount of frost injury. With trees well established it is reasonable to suppose that the summer rains will counteract somewhat the effect of high temperatures of July, August and September.† With the advent

*Data on rainfall from Bulletin 64, University of Arizona, Agricultural Experiment Station.

† "The surface layers of the soil reach a temperature of over 100° F. during the summer months." The Course of the Vegetative Seasons in Southern Arizona.—D. T. MacDougal, The Plant World, Vol. II, No. 8, September, 1908.

of fall the temperature drops gradually and with the absence of rainfall, growth is checked. During December and January, the secondary maximum of precipitation occurs, usually amounting to from two to three inches. While a checking action is exerted during this season by the low night temperatures, which frequently drop to 20° and even lower, the combined effect of the moisture and dry temperatures is such as to place the tree in a condition susceptible to frost injury. The occurrence of this injury is principally dependent on the range of temperatures immediately preceding the drop. The gradually rising minimum temperatures of the early spring months remove danger from frost injury. Favorable temperature for rapid growth obtain, but there is almost an entire absence of moisture. This is really the critical period and brings the discussion to the real point at issue, namely, the relation of the moisture supply to the plantation.*

Authentic records are found where certain species of eucalyptus have endured droughts of considerable severity.

Prof. McClatchie notes (Bulletin No. 35), having observed at the close of the season of 1900, the driest one of which the Weather Bureau has record, rostrata, corynocalyx, and tereticornis growing without irrigation in a neglected tract in southern Arizona, where the ground water was 100 feet below the surface. Other examples may be found. This important fact, however, should be noted. In the above cases the trees had been well established by irrigation before the occurrence of the drought. In fact, in no case has the writer found an example of the establishment under desert conditions of a plantation or individual trees where a plentiful moisture supply has not been furnished them during a period of years succeeding the planting. While those who have studied the possibilities of eucalyptus culture in southern Arizona have recognized the need for a plentiful moisture supply during the years of establishment, it is believed that the importance of this point has been generally overlooked by those who have advocated the employment of eucalyptus for the purposes of forest cover in the Southwest.†

In the particular tract under consideration no sites of any extent are

*"On the mesas and mountain slopes and up to altitudes of 4,500 feet or thereabouts, the most important consideration so far as growing plants are concerned, is that of soil moisture, i. e., summer or winter growth obtains at the lower altitudes whenever there is sufficient moisture in the soil, favorable temperatures being for the most part constant factors." Relation of Plant Growth and Vegetative Forms to Climatic Conditions.—J. J. Thornber, The Plant World, Vol. 12, No. 1, January, 1909.

† "In order to get the seedlings started it would be necessary to water and cultivate them a year or two, after which they would be supported by the

found where the ground water is sufficiently near the surface to sustain eucalyptus growth, even provided the trees could be established by a few years of irrigation. In fact, the sole available moisture supply lies in the rainfall, so decidedly irregular in amount, so markedly less than the possible evaporation, and so unevenly distributed with respect to the thermal growing seasons as in the opinion of the writer, to render the formation of eucalyptus plantations a practical impossibility.

Upon what data are these conclusions based? Purely upon a study of a few of the most drought-resistant species which have been introduced to some extent in the Southwest. In discussing the possibilities of the genus in southern Arizona Professor McClatchie states: "The tests of various species made in Arizona by the writer during the past three years, indicate that there are species of eucalypts adapted to many regions where they have not been tried. These experiments indicate also that in localities where it has been supposed they could not be grown successfully as forest trees, suitable varieties have not been tried. There is need of a careful study of these trees in their native habitats, in order to determine what species may be introduced into regions with climate and soil similar to those of the districts in which the respective species grow naturally."

In forming these conclusions it may be that too great weight was placed upon the temperature requirements and too little upon the moisture demands of the species concerned. Thorough experimentation alone will determine this. As Professor McClatchie says, "A more careful and systematic study of the genus, accompanied by cultural tests will undoubtedly result in the discovery of additional and probably better species for these and other regions." Whether species adapted to the gravelly desert slopes of this region will be found, remains to be proven. Here lies the field for research. A study of the interior desert regions of Australia, with particular reference to the introduction of suitable species into the Southwest, would throw considerable light on this subject. Pending the introduction of such species, if they exist, the writer is constrained to limit his conclusions to those above cited.

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rainfall, especially in localities where the ground water is near the surface." Bulletin 35, Forest Service.

"If the most drought-resistant varieties of eucalypt trees are once well established during a period of wet years, or, better yet, by means of moderate irrigation, there appears to be good cause to believe that they may be grown successfully with limited irrigation on lands that are of secondary value for cultural purposes at the present time on account of limited water supply."

"However, the writer would warn the practical planter not to expect too much from trees growing with a limited water supply." Bulletin 68, University of Arizona, Agricultural Experiment Station.

NOTES ON MANAGEMENT OF REDWOOD LANDS

SWIFT BERRY

(Contributed)

The following notes on redwood logging and cut-over lands are based upon observations taken upon the lands of the largest lumber companies operating in Humboldt County, California, ranging in location from Trinidad on the north to Korbel in the east and Holmes on the south.

The various operations differ somewhat in the smaller details of logging, but the methods of felling are practically the same throughout. Redwood, because of its large size, is felled with a saw, two men working together. The notching for felling is done with axes. In order to prevent all possible breakage, proper notching is of the utmost importance and requires experienced labor. Since redwood is very brittle and breaks at each inequality of the ground when felled, the most time-taking part of the operation is the preparation of a bed in which the tree is to fall. The small timber upon the tract is utilized for this purpose. Logs are cut from it and rolled into each depression by jackscrews until the bed presents as nearly a plane surface as possible. This work usually consumes much more time than the actual felling, and the entire operation in the case of a large tree frequently requires as many as three days. Even with this amount of care the loss from breakage in the best conducted logging operations varies from 10 to 20 per cent, and in some cases probably equals 25 per cent. It is encouraging, however, to note that all operators are requiring greater care and more time to be spent in felling, which of course will tend to constantly decrease the amount lost by breakage. Practically all of the operators still cut the timber absolutely clean as they go. On one tract at Holmes, where the practice of cutting over the area twice has been followed, it was evident that the loss from breakage had been lessened considerably and that the cost of logging remained at about a standstill. Therefore, it would seem desirable in the heavier stands, because of the breakage prevented, to fell and log one-half of the timber at a time.

After felling the trees are trimmed and immediately peeled. Rings are chopped at ten-foot intervals and all bark possible is removed with crowbars. Operations cease temporarily at this stage and the timber lies for three or four months before burning is attempted. It is possible

that if the area was gone over before burning and logs cut from broken trees and rolled aside with jackscrews, the loss from burning would be lessened. The loggers admitted that this seemed practicable but none could be found who had tried it.

When some five or six million feet board measure have accumulated upon each cutting area, fire is set out and the cutting burned over. This fire is for the purpose of removing slash and debris in order to render logging easier. This it does in an excellent manner, but at the same time all reproduction is destroyed as well as a large amount of merchantable timber. Although the redwood is very fire resistant, the fire enters all rotten, split or badly broken logs and burns therein for days, frequently until the log is completely hollowed out. Also small logs, tops and materials used in bedding are often entirely consumed. Logs lying across one another are invariably burned in two. In ordinary burning this loss approximates 15 to 20 per cent of the stand. In some cases this loss is now being reduced by extinguishing the fires in individual trees with water squirt-guns, after the main fire has passed.

In the majority of the operations visited the debris resulting from bedding, trimming and peeling was not so great but that logging would be feasible without burning, though of course it might be slightly more expensive. One of the most competent logging foremen agreed that such a course was practical, but stated that it would increase his cost of logging. However, it is certain that the value of the material saved by this practice would more than compensate for the additional cost of logging. The only logging on unburned land seen was upon a setting near Shively which had been too wet to burn. Logging here was very much upon the same basis as in other operations except that a little more time was required to adjust the slings. Though admitting that logging before burning might be advisable, operators were unanimous in declaring that the area must be burned ultimately, since they could not afford to run the risk of placing their equipment in such a slash, where it might be destroyed by fire any time during the summer months. Under present fire-fighting methods their contention is undoubtedly good, but fire patrol and clearing about each machine would lessen this danger considerably.

After burning, the trees are sawed into log lengths and logs too large to be handled singly are split with dynamite. All logs are slightly nosed to allow them to slip past obstructions in snaking. The next step is the construction of logging railroads and skid roads.

The actual logging is invariably accomplished by skidding the logs from the woods to the railroad with steel cables drawn by donkey engines. Two general methods are in vogue. Large "Seattle" donkeys bringing in

the logs singly or by twos in cable slings is adapted to the flatter localities and for distances not exceeding one-quarter of a mile. For hillsides and longer distances bull donkeys hauling in trains of 8 or 10 logs at a time are used. For loading upon the cars separate cables operated either by a small donkey or by a separate spool upon the large donkey are used.

By comparison with old cuttings one is pleased to note that redwood operators are gradually reducing the height of their stumps, though often in the case of small timber the height might still be reduced by two feet. In the worst cuttings the height of stumps averaged from 5 to 6 feet, whereas in the best work seen the average height was about 3½ feet. The cutting of low stumps is encouraged by the resultant saving of some of the best timber in the tree and the fact that the lower the stump the less breakage occurs. Tops are cut out as far as they will make a log, which most loggers consider about twelve and some ten inches.

After logging is completed, gangs of men travel over the area and cut all remaining sound material into shingle bolts, which are sledded out to the railroad. Very little merchantable redwood is thus left upon the area after logging, though there remains a considerable amount of rotten and broken material which offers excellent fuel for forest fires.

Cut-over Lands

Three principal methods of handling newly cut redwood land lie open to the owner—namely, as farm land, grazing land, or forest land.

The bottom land along the valleys of the above region is first-class agricultural land, and the quantity and quality of the grain and fruit crops now being produced upon this class of land indicate that its best returns may be secured by agricultural usage. Only a comparatively small amount of such land is covered by redwood, but it is certain that it will ultimately all be utilized for agricultural purposes. Such utilization is, of course, made very slow by the initial cost of clearing the land. Several burnings are required, after which the stumps must be blown out piecemeal with dynamite. Such work is very expensive and approaches a total of $100 per acre, which exceeds the present value of the cleared land.

Nearly all of the redwood is located upon hillsides or table lands, and therefore not upon lands at present suited for farming purposes. Practically all of this land may be utilized to some extent for grazing, and dairying is now one of the important industries of the country. To make good grazing land of cut-over redwood forests, the brakes, brush, and sprouts following cutting must be kept out and the grass allowed to

come in. This is generally accomplished by repeated burning, which finally kills all the coppice growth and ultimately allows the grass to come in nicely. A tract near Arcata which has been burned over biennially for the last ten years appears to have become permanent pasture land, and the redwood stumps show no signs of life. A tract upon a north slope near Trinidad, burned over three times in the last five years, still shows signs of coppice growth and is yet poor grazing land. North slopes produce a more profuse growth of brakes and shrubs, and are therefore more difficult to convert into grazing land. Some very good grazing land occurs on the east side of the Eel River, extending in a strip about 9 miles long between Scotia and Shively. This land was cut over from 8 to 20 years ago, and has been burned over very few times since logging. Grass has finally succeeded the brakes and the redwood sprouts are alive and making excellent growth. Thus a sort of combination between a forest growth and grazing land is secured.

Redwood land cut over near Bayside, 30 to 35 years ago, now has a sprout growth large enough for the manufacture of ties, telephone poles, and some trees are of sufficient size to cut a low grade of lumber. Fire has at no time visited this tract after the logging operations. This, with other similar examples, leads one to believe that redwood sprout land offers possibilities as an investment. There are two drawbacks One, the unevenness of the resulting stand, may be remedied by interplanting with some species, possibly eucalypts. The main obstacle, and one which must be overcome before this treatment of redwood land will become general, is forest fire. Some localities seem easily protected from fire, while in others it is almost an annual occurrence. The latter are increasing, owing to the general cutting away of the timber which allows the summer winds free sweep. From July to September, inclusive, is the fire season in the redwoods, and is also a season of north winds. At this time all growth upon the cut-over lands becomes very dry and offers every opportunity for fire. When fire once enters the cut-over areas it is very difficult to stop, and usually burns out to the standing timber. Concerted action among timber landowners would do much toward averting the fire danger. Patrols should be established; fire-lines constructed; fire-fighting equipment placed in convenient places; stringent regulations regarding smoking and use of fire in all camps should be adopted, and the State fire laws should be enforced. By such means the ownership of cut-over redwood land restocking in the same species will be made a desirable thing.

EFFICACY OF GOATS IN CLEARING BRUSH LAND IN THE NORTHWEST

C. S. JUDD

(Contributed)

Location and Physical Character of Area

The area investigated consists of approximately 120 acres of patented land in the Wind River Valley, Washington, within the exterior boundaries of the Columbia National Forest. It is situated in the bottom-land, where the valley of Panther Creek broadens out and merges into the Wind River Valley. Panther Creek, a rushing mountain stream of clear green water, borders the eastern part of the area, running down through a narrow, steep-sided gorge 50 feet lower than the general elevation of the surrounding land. In about the center of the area a rounded hill, approximately 120 feet high, rises abruptly and extends northward in the form of a ridge. The soil is a fresh, deep forest loam of excellent agricultural value. Rock is absent except along the eastern portion of the area where Panther Creek has cut down to the lava bed rock.

The whole area was originally covered with a dense forest of Douglas fir, western hemlock, grand fir, and a few scattered trees of western red cedar and western white pine. There was also a greater proportion of vine maple, yew, and dogwood undergrowth than is usual in a forest of this type.

The great fire of 1903 killed the greater part of the trees. The merchantable burned timber was logged soon after the fire and the area was again burned in 1905. Immediately after this last fire timothy grass was sown with the intention of converting the area into a pasture. Soon after young seedlings of Douglas fir made their appearance, but those which were not choked by the timothy were trampled down and destroyed by the few head of cattle that were turned in to graze. About 6 acres, however, at the northern end of the area escaped the 1905 fire, and the Douglas fir seedlings which started here soon after the 1903 fire seem to have escaped injury by the cattle. After the second fire the vine maple and dogwood sprouted vigorously from the old stumps and appeared in clumps well scattered over most of the area.

At the present time the area presents a very unsightly appearance. Charred stumps, standing snags and fallen logs cover a large part of it, and the only living forest trees are a few small, sickly Douglas fir scattered singly and in groups upon the hill.

In the southern central part of the area about 8 acres have been enclosed by a barbed wire fence. About 6 acres of this are now planted to oats and the remainder north of the goat tender's house on the hillside is planted with apple trees.

Before the goats were placed on the area the ground in places was covered with a dense mat of wild blackberry vines. In fact, this was a favorite picking ground for the near-by settlers. Clumps of vine maple and dogwood sprouts from 6 inches to 5 feet high were quite evenly scattered over most of the area. Here and there young seedling willow and hazel bushes grew singly, and in the northwest portion of the area were Douglas fir seedlings up to 7 feet in height which the second fire had not destroyed.

Before the owner purchased the goats, he constructed a wire fence around three sides of the area, the fourth side, on the east, being impassable by reason of Panther Creek. This fence consists of round posts 8 inches in diameter, 5 feet in height above ground, set 20 feet apart. The posts are strung with 6 smooth wires of number 12 gauge. The lowest wire is 4 inches above the ground, and the distances between the lowest and the second lowest wire and so on up to the sixth wire at the top are respectively 6, 7, 8, 10, and 13 inches, the top wire being 4 feet above the ground. At distances of 3 feet 4 inches apart 5 wire stays are woven into the wire between each set of posts. One pound of number 12 smooth wire will make one wire 16½ feet long. Wire of this size costs 3½ cents per pound.

Such a fence is not efficient in keeping the goats absolutely confined within the area, since they can not only force themselves between the wires, but can also jump over the top of the fence. This they do by leaping up on to the top of the post and then jumping down to the ground on the other side. In places fallen logs and stumps occur along the fence, and on these it has been found necessary to nail upright battens set close together to keep the goats from jumping from such vantage points over the fence.

The fence surrounding the oat field and the apple orchard is similar to the exterior fence except that barbed wire is used and the posts are set 10 feet apart with only 2 wire stays between them. A part of this enclosure is built of split rails nailed 4 inches apart to posts which are set 10 feet apart. This fence seems to be quite effectual in keeping the goats out of

this cultivated field. Evidences of numerous attempts to enter this enclosure are presented by bunches of mohair caught on the barbs of the wire.

A fence of the following description would, I believe, be absolutely effectual in confining goats to any particular area. Posts should be set 20 feet apart with 7 feet showing above the ground and the tops sharpened to a point so as to afford no perch for the animals. To these posts should be strung 8 barbed wires, the lowest 3 inches above the ground, and the remaining 7 from the bottom up, respectively, 4, 6, 7, 8, 8, 12, and 12 inches apart, the top wire being 5 feet above the ground. Five wire stays each 3 feet 4 inches apart should be woven into the wires between each set of posts. Care should be taken to clear fallen logs away from the fence so that the goats can not use them as jumping points, and where the wires cross depressions in the ground obstructions in the form of earth heaped up or small logs should be placed beneath the lowest wire to prevent the goats from crawling under the fence.

Shelter of some sort seemed necessary for the goats, and this has been provided in the form of a log cabin barn 50 feet by 60 feet with a high roof made of dimension stuff and shakes. There is a large bin for hay, built on the ground, which is floored with logs and sided with boards. The rest of the barn floor is bare ground and the barn is boarded in on all sides.

The goats were purchased in November, 1907, with the purpose in mind of placing them on this area in order to clear the land of brush. The goats were obtained in separate lots from Forest Grove, in the Willamette Valley, Oregon, and consisted of 189 in all. They are of the angora breed, bearing the mohair or goat wool, which is of commercial value. The owner paid $500 for one lot of 60 and $40 for another lot of 17 goats. Among these are two billy goats, one of which is said to be worth $20. At present there are about 156 goats left.

The goats have not been entirely confined to this fenced area, and for this reason full evidence of what this number of goats could do if confined strictly to an area of this size is not available. The goats have not only jumped the fence and browsed on a large area surrounding the enclosure on the west bank of the river, but a log has been placed across Panther Creek near the goat barn, and the goats cross on this and spend a large part of their time browsing on the steep hillside on the east side of the creek.

A goat tender lives in the house near the apple orchard and his duty is to care for the goats. He says that they are more bother than they are worth, as they often wander into the thick brush and get lost and have to

be driven back. Sometimes they get caught by the horns and would starve to death if not liberated. They seem to be very stupid animals and when in difficulty give up easily. Cougars have killed two of the goats and a timber wolf took away several. Bob cats also are fond of goat flesh, so that the goat tender is constantly on the watch for these predatory animals.

The goats are free to roam all the year round. They usually come back to the barn at nightfall, especially when the weather is at all rainy. When the browse is covered with deep snow, timothy and clover hay is fed to them at the barn. The goat tender says that three goats will eat as much as one horse.

The goats were sheared of their hair during the first part of March, and the hair, which was not of very good quality, brought only 20 cents per pound.

Results of the Experiment

The goats have been on the area now for 16 months, and have browsed on the vegetation all of this time except when the depth of snow made this impossible. Their efficacy in clearing and keeping the land clear of brush is certain.

The following is a list of species on which the goats will browse in the order of preference, as nearly as could be determined:

1. Fern
2. Vine maple
3. Dogwood
4. Elder
5. Willow
6. Red huckleberry
7. Wild pea
8. Thimbleberry
9. Hardhack
10. Alder
11. Raspberry
12. Blackberry.
13. Oregon grape
14. Salal
15. Hazel
16. Black cottonwood
17. Wild rose
18. Wild cherry
19. Fireweed
20. Douglas fir
21. Western hemlock
22. Western yew

In addition to these the goats have been caught in the act of nibbling the bark of the apple, pear, and cherry trees.

Half of the clumps of vine maple and dogwood sprouts, the most abundant shrubs on the area, were killed outright by browsing, and on other clumps the tips of 3-year-old sprouts have been nibbled clean off and the sprouts have died down as much as 24 inches. Tips of dogwood branches 8 feet above the ground have been nibbled by the goats, and alder, willow, and dogwood trunks from 2 to 3 inches in diameter have

been completely girdled by the chisel-like teeth of these animals. On an area of three acres around the barn there is not a living shrub in sight.

The goats will not touch Douglas fir unless hard pressed for food, but at times they must have been very hungry, for Douglas fir seedlings as tall as 6 feet were discovered entirely stripped of every leaf, and branches as high as 7 feet have been nipped off. The leaders and side branches of smaller Douglas fir have been nipped clean and many have thus been killed outright.

The only species discovered which it is certain the goats should not eat is the wild parsnip. This is poisonous, and in a number of instances has proved fatal.

From the observations made of the effect of goat browsing on this area, the author is led to believe that goats are a most efficient means of clearing areas of brush land when properly confined to the areas by suitable fencing.

For Per

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THE ESSENTIALS IN WORKING PLANS FOR NATIONAL FORESTS

BY BARRINGTON MOORE

(*Contributed*)

This article deals but briefly with the essential features in a working plan. Some salient points, here merely touched upon, will be treated more fully in future papers. It is written primarily to assist, if only in a small way, men in the field who are charged with the making of working plans.

Field Work

Extensive methods of reconnaissance must eventually be abandoned, for the data obtained by such methods, although they show roughly the resources of the Forest and indicate what parts of the Forest are most in need of cutting, cannot serve as a basis for working plans. The best methods now in use are: The ocular estimate and map by "forties," the estimate being checked by the estimator with occasional sample acres, circular or strip, and afterward by the Chief of Party or Inspector of Reconnaissance; and where the Forest is too dense to allow a representative portion of the "forty" to be seen, the strip method, in which actual tallies are kept. Under the ocular method the accuracy of the men's judgment is also carefully tested and brought up to standard once a month by thorough drills on sample "forties." In unsurveyed or poorly surveyed country a base line, which about doubles the cost of the work, must be run in order that the "forties" may be accurately located. These

methods require well organized and well equipped crews of four to eight men, and involve a cost of approximately from 1.5 to 6 cents per acre. The data obtained, however, when supplemented with growth figures, serve as a fairly reliable basis for making a working plan, and experience is beginning to show that the newer methods of reconnaissance have brought about results far more valuable than the proportionate increase of cost.

Unit of Area Covered by a Working Plan

The variety of opinion concerning the size of the area which a working plan should cover indicates a regrettable lack of knowledge and lack of a thorough sifting down of the subject. The ideas here expressed do not presume to be final, but, it is hoped, may start discussions which will aid in bringing about a more definite policy with regard to this important matter.

The chaotic condition of this subject strikes one forcibly on reading the first pages of Mr. Kirkland's article on Working Plans, published in the last number of the Proceedings (Vol. VI, No. I). It is amazing to note the amount of space which he considers it necessary to devote to arguing for the regulation of the cut by National Forests or part of Forests as units as against the regulation of the cut for the District as a whole. It seems incredible that a forester could conceive of any single working plan or mere plan for regulating the cut which applies to 25 different and widely scattered National Forests, covering an area of 54,657,378 acres and dealing with an innumerable range of conditions, as anything but the roughest and most temporary kind of a makeshift. It is possible that to attempt regulation of the cut with a whole District as a unit may be better than nothing. But it is imperative that it should take in only those National Forests on which no local communities are dependent and should be replaced at the earliest by regulation for individual National Forests. This will be but the second step, little in advance of regulation by the District, and to be replaced again by regulation based on working circles as soon as the data become available. Take for example a case of regulation with the National Forest as the unit: We know that there are 400 million feet of timber on the Forest, and that it will be safe to cut 20 million feet a year. The restriction of the cut to 20 million feet will prevent overcutting on the Forest as a whole. But even a single Forest covers a large territory, and there is nothing in the above regulation to prevent a heavy overcut on one part of the Forest tributary to a certain market, and little or no cutting on another part tributary to a different market. The result will be that, as

far as stable conditions in the communities dependent on the Forest are concerned, we shall be no better off than before. Obviously the same thing would be true, only to a far greater degree, with the regulation of the cut for the whole District.

Since the chief aim of a working plan is to prevent just such irregularities in the cut, the first essential is to divide the area to be covered into working circles. This should be done at least roughly before the field work, when the working-plans officer (man in charge of a reconnaissance party) goes over the ground to lay out the work. The final division need not be definitely decided upon until all the field data have been gathered and the working plan is actually in the making. It is, however, of the utmost importance that the working-plans officer keep this division into working circles in mind as the field work progresses.

The basis for the division into working circles is geographical situation and markets. It is evident that the parts of the Forest in different locations and tributary to different markets will require distinct regulations of the cut. If neither of two markets require sustained yield for the present, it would be possible temporarily to combine both divisions into one working circle. But as soon as one or both markets begin to require sustained yield the regulation of the cut for each will have to be kept separate.

Where the management becomes intensive silvicultural types and silvicultural systems will also form the basis of working circles. The results may be to include one working circle within another. For instance, in the Chir pine (*Pinus longifolia*) belt of India an oak working circle, in which a sustained yield of oak fuel wood is provided under a system of coppice with standards, is situated in the heart of a Chir pine working circle managed for a sustained yield of saw-timber under the shelterwood compartment system. Even in this case each working circle is distinct from the other and has a separate working plan. In Mr. Kirkland's working plan the division into working circles is made; but in his article the basis of this division is not clearly explained. Markets, the fundamental basis of any division into working circles, are not mentioned, though they were undoubtedly considered. The word "districts" for working circles seems ill-chosen, since it is liable to cause confusion with ranger districts, besides the fact that there are already enough units in the Service called districts. The word "division" seems sufficiently distinct and explanatory.

The important point to keep in mind is that each working circle (unless combined as mentioned above) requires a separate and distinct regulation of the cut. In the final working plan of the Forest, the plant-

ing plan, administrative plan, fire plan, and permanent improvement plan may be combined for the whole Forest if found convenient; but the plan for regulating the cut, the most important part of the working plan, must be kept separate for each working circle.

So far the chief trouble with all attempts at making working plans, in the Southwest at least (and it is doubtful whether it is any better in other districts), has been that the estimates for the whole Forest were bunched together, a formula applied, and the result called a working plan. Naturally enough it failed to work.

Arrangement

The arrangement of the subject matter in working plans is fairly well given in the original outline for working plans gotten out by District 3, but will be briefly reviewed here on account of a few changes:

Introduction (for the whole Forest).
- General location and importance of Forest.
- Historical creation of Forest and changes in boundaries.

(The following for each division (working circle):

Name of division.
- Introduction.
  - Time of work, area covered, and personnel.
  - Method employed.
  - Conditions of work and cost.

Part I. General Data.
- Status.
- Physiographic features.
  - Geology and soils.
  - Climate.
- Social and industrial.
- Forest description.
  - By blocks or types.
- Utilization.
  - The demand.
  - Methods of removal for lumber.
  - Methods of removal for all other important products.
- Revenue and expenditure.

Part II. Maps and Estimates.

(A brief description of the maps and estimates which have been made, the maps and detailed estimates themselves being put in the appendix.)

Part III. Working Plan Proper.
- Objects of management.
- Silvicultural systems.
    - For each Forest type.
- Marking rules.
    - For each Forest type.
- Brush disposal.
- Regulation of the yield.
    - Rotation and felling period.
    - Division into blocks and compartments.
    - The working capital.
    - Calculation of the yield.
        - Method of calculation, giving actual examples.
        - Calculation for each important species.
    - Allotment of the yield.
        - Method of allotment.
        - Actual allotment.
    - Summary of logging conditions by blocks or compartments.

Part IV. Planting Plan.
- Areas needing artificial regeneration.
- Methods of regenerating.

Part V. Administrative Plan.
- Ranger districts.
- Force.

Part VI. Fire-protection Plan.
- Lines of patrol and lookout points.
- Division of patrols into ranger districts.
- Lookout towers or telephone steps on lookout points.

Part VII. Permanent-improvement Plan.
- General.
- Telephone.
- Lookout towers.
- Fire cabins.
- Trails.
- Ranger stations.

Part VIII. Grazing Plan.
- Description of types.
- Condition of range.
- Unused range.

Part VIII. Grazing Plan—Continued.
- Poison areas.
- Prairie dogs and other pests.
- Water facilities.

Appendix

General data.
- Geology and soils.
- Climate.

Silvical data.
- Detailed growth studies.
- Silvical notes (for each species).
  - Influence of elevation and aspect.
  - Soil and moisture requirements.
  - Tolerance.
  - Reproduction.
  - Age classes, distribution of.
  - Fire resistance.
  - Injuries.

Supervisors' Administrative Plan.

Supervisors' Fire-protection Plan.

Supervisors' Permanent-improvement Plan.

Miscellaneous.
- Matter not properly part of working plan, such as a discussion of advisability of a new sale.
- List of species.

In the above outline there may seem to be repetition in the appendix of subjects already occurring in the body of the working plan. The reason is that in the body of the working plan everything is treated as briefly and as concisely as possible and is later taken up in detail in the appendix. This avoids the unwieldiness which has been a marked characteristic of most plans so far made. The point is one which it is well to keep in mind in drawing up a working plan.

Points in the Working Plan

Introduction

Under the introduction the "Time of work, area covered, and personnel" are of general interest, but the most important part is the "Method employed." This gives the reader and the men charged with the execution of the plan an idea as to the accuracy with which the maps and estimates have been made and is therefore indispensable in all future

work requiring their use. When field methods have become completely established and well known throughout the Service, it will not be necessary to more than refer to them in the body of the plan and give the details in the appendix. But, on account of the present stage of change and development in methods, the subject is now sufficiently important to deserve full treatment in the body of the plan.

General Data

Although the information under "General data" should be boiled down and given concisely, yet this should not be done at the expense of completeness. Though it may sound axiomatic it is sometimes forgotten that there will be certain information in the "General data" without which no working plan can be made.

The "Status" of the land included in the Forest will sometimes exert a marked influence both on the silvicultural treatment and administration of the Forest. If a Forest is badly cut up with alienated land, certain measures otherwise desirable and easy of application may be rendered extremely complex or even impossible.

The "Physiographic features," under which are commonly included "Topography, drainage, geology, soils, and climate," will influence the choice of the silvicultural system, the marking rules, the brush disposal, and, through them, the entire regulation of the cut. Knowledge of the climate is not only necessary from a silvicultural point of view and to show the productive possibility of the Forest (*e. g.,* in the Southwest rainfall is the factor positively determining the existence or non-existence of forests), but it is of vital importance in drawing up the plan for protecting the Forest against fire.

"Social and industrial information," under which are included "Population, labor supply, local industries (lumbering, grazing, agriculture, mining)," and the needs of the local population for free use, is indispensable in drawing up timber sales and in a proper administration of the Forest. For instance, in deciding upon the provisions of a timber-sale contract, it is well to know not only where the purchaser's labor is to come from and how much he must pay for it, but also the class of men with whom it will be necessary to deal. In general administration an illiterate and ill-disposed population always complicates most problems, particularly that of protection against fire.

"Forest description" is one of the most important and yet most frequently slighted parts of a working plan. It is needed in any timber sale, as being part of the information which the officer making the sale would obtain if he were sent out to make an examination of the area. Since

one of the aims in drawing up a working plan is to obtain all the necessary field information, so that a sale can be made at any time without the expense of sending a man out, the working plan should contain this information. Forest description is essential not only for this purpose, but also as forming the basis of all the silvicultural recommendations in the working plan; on it depend the silvicultural systems, marking rules, brush disposal, and regulation of cut; in fact all of the purely scientific part of the plan. It has hitherto been more or less shirked by reconnaissance men, because of its inherent difficulty and their inability to make anything but a tiresome and futile discussion of it. Then, too, many fail to see the true scientific viewpoint beyond the all-absorbing work of mapping and estimating. The common objection as to the length of Forest descriptions can be obviated by relegating all details of silvicultural value which have heretofore been included in "Forest description" (when included at all) to the appendix. In addition to "Forest description," purely silvical notes of distinct value can be made by the working-plans officer and the technical men of the party in connection with the regular field work. These also should be placed in the appendix.

"Utilization" is a subject the significance of which may be seen at a glance. It is almost *sine qua non* of the qualifications of a working-plans officer that he be thoroughly familiar with all local market conditions and with all the methods and detailed costs of lumbering or of extracting whatever product the region demands, such as mine timbers, cordwood, etc. If the working circle contains more material than can be absorbed by the local markets, and must depend to a certain extent on export markets, he must also be familiar with the conditions of the lumber market in other parts of the country; he must know the freight rates, the prices at the large lumber centers, the sources of competing timber, tendencies in other parts of the country, and any other factors (such as the influence of the Panama Canal on transportation) which may have a bearing on the price of lumber. On all these things depend not only the provisions of the timber-sale contract with regard to closeness of utilization, but also the regulation of the cut and a stumpage price which shall be fair to both the purchaser and the Government.

A paragraph on "Revenues and expenditures" takes up but little space and is of interest as showing whether or not the Forest is self-supporting, and as an indication of what is to be expected in the near future.

Maps. Though the function of maps in working plans needs no comment, mention should be made of the different kinds of maps. In the first place contours are preferable to hachures, where the work is intended to be in any way final. The first map called for is a topographic

map, giving Forest types and the boundaries of the Divisions (working circles, blocks, and compartments, together with all sawmills and cutting areas). If the cut is to be regulated on the basis of area with a volume check, a map showing age classes and site qualities is necessary. Under either the area or volume method of regulation, a stand map giving the volume per acre is helpful but not indispensable. It is of more value under the area than under the volume method. Each plan given in the foregoing outline (the planting plan, administrative plan, fire plan, permanent-improvement plan, and grazing plan) requires a map in order that too much data be not placed on one map; it is better to have separate maps than try to combine too much and cause confusion. The planting-plan map should be the original topographic type map, with all areas requiring artificial regeneration, areas already planted or sown, and nurseries and proposed nursery sites. The fire-plan map should be the topographic type map, showing all lookout points, watch towers, lines of patrol, Ranger headquarters, fire-guard stations, location of fire-fighting tools, and places whence assistance in fighting fire may be obtained. Topography and types are of great importance in fighting fires. The administrative and permanent-improvement maps may be combined in one; no topography except the main ridges and streams is necessary, but all improvements, such as Ranger stations, fire cabins, telephone lines, roads, trails, corrals, pastures, drift fences, watch-towers, water tanks, etc., together with the boundaries of Ranger Districts, should be given. The grazing map should be the topographic map on which, instead of forest types, grazing types are shown, together with the condition of the range; the portions grazed and not grazed; the winter, summer, and year-long range, and all water facilities. The planting, fire, administrative, permanent improvement, and grazing maps may be made after each Division of the Forest is completed, and then combined into one map, or made altogether after the whole Forest has been covered. The maps for use in regulating the cut must be made as soon as each Division is completed.

In addition to the above maps a set of blank township plats should be kept for putting in the status (alienations), June 11 claims, and special uses.

Working Plan Proper. The "Object of management" can easily be determined from a knowledge of the area and of market conditions, and should be kept constantly in view, both in the field work and in the final preparation of the plan.

Silvicultural systems must be drawn up for each important Forest type, and should be based entirely upon the forest description and silvical

data (growth figures and silvical observations). The working-plans officer should not go into the field prejudiced in favor of any one system, because he is then in danger of seeing only such phenomena as tend to prove that this system is correct. He should keep his mind open, see everything, and draw his conclusions accordingly. Although the principles on which silvicultural systems are based should be constantly kept in mind throughout the work, yet the systems themselves should not be finally decided upon until all the data have been thoroughly worked up.

The next step will be to draw up a careful set of marking rules which shall insure the putting into practice of the silvicultural systems decided upon. These should be sufficiently elastic to cover all cases, very clearly stated, and should be as nearly as possible the rules of guidance which the working-plans officer, with his knowledge of the silvical requirements of the tree, would set before himself if he were actually marking a timber sale. Of course, they should be expressed in such language that they can be readily understood by Rangers with little or no technical training.

It is no exaggeration to say that the marking rules are the most important part of the entire working plan, because on them and on their proper execution depends the entire silvicultural future of the Forest.

In a general paper of this character it will not be possible to more than skim over the vast field of regulation of cut. The choice of rotation must depend upon the growth figures and the object of management. It should not be difficult to get a better basis than that given by Mr. Kirkland in his article on working plans previously referred to, namely, "The use of a comparison of similar species in other countries" and "Crude yield tables." It would seem obvious that the roughest kind of stump counts made in the region would have been more reliable. His use of a financial rotation is also open to question. A financial rotation is well enough when it does not interfere with other objects, which to the government should be of greater importance; but it is hardly adapted to the practice of extensive forestry or justified by the data which he had on hand. Therefore, until safer and more reliable data are available and until more intensive methods become practicable, it would probably be wiser to stick to a simple maturity rotation.

The division into blocks and compartments should, of course, be made on the basis of topography. In general the block should be a group of logging units and the compartment a single unit. The subdivision of the block into compartments is too intensive for the conditions on many National Forests at the present time.

The method of regulating the yield will depend upon the silvicultural condition of the Forest and the data which it has been possible to obtain.

For instance, in a Forest which is uneven-aged, requiring a selection system, regulation should be on the basis of volume with an area check. If the strip method of estimating has been used and accurate stand tables obtained, it will be possible by applying growth figures to obtain the increment per acre.* If nothing more than growth figures and estimates have been secured, a growth per cent must be used. The well-known Austrian formula, supplemented with careful judgment in distributing the surplus, will give results sufficiently accurate for all practical purposes. Where a Forest is even-aged the regulation should be by area with a volume check. This involves stand tables, growth figures, and a map giving site qualities and age classes. The allotment of the cut is made by deciding upon certain areas producing an equal volume. Under either system it is necessary to give the cut in detail for only the first part of the rotation and then approximately for the last part, since a revision of the working plan should be made periodically, usually every 10 years. It will be well, until methods of regulation are more generally understood, to give the details of the method very thoroughly in the plan.

The final allotment of the cut under any method of regulation should be made with due regard to local needs. For example, if there are a number of industries demanding wood to such an extent that an overcut results, and if restricting their cut to an amount which will produce sustained yield will involve crippling their operations, it will be wiser to allow them to continue cutting until the supply is exhausted and they are forced to stop automatically than to cripple them in such a way as to risk their immediately stopping operations altogether. In many cases a sale made before the reconnaissance work was done, though it results in an overcut, must be continued because the Government is under a moral obligation to the purchaser. Where timber is not needed for local markets and is mature, it is good policy to have it all cut at once (provided it can be sold), even though the result be a complete blank in the yield for a considerable period of years. Of course, where it is feasible, sustained yield should be aimed for, but it should not be the sole object of the working plan, without which, as is sometimes thought, it ceases to be a working plan, nor should too many practical considerations be sacrificed in order to secure it.

Other Plans Forming Part of Working Plan. The planting plan, administrative plan, fire plan, permanent-improvement plan, and grazing plan, though subordinate to the timber plan, are essential to a complete

* In dealing with virgin stands it must be remembered that in an overmature tree which has begun to deteriorate the growth is often balanced by the decay.

working plan. They should be drawn up with much care and only after they have been discussed in detail with the Forest supervisors; then their provisions will be of real value to the future work of the Forest.

Hitherto the timber plan has been placed in the files with the other plans, all being considered of more or less equal importance. This was logical when the timber plan was nothing but a mere rough regulation of the cut, or a map and many estimates thrown together with the name of working plan, as with the early attempts; but as forest management becomes comprehensively understood and better organized it will be recognized that these various plans belong together as the proper parts of a single, homogeneous working plan. The regulation of the cut and data upon which it is based must be kept separate for each Division of a National Forest; the other plans may be kept separate or combined, whichever is most convenient, but each performs its particular function in the enforcement of a well-made working plan.

To summarize, the more important points brought out are:

1. Regulation by Districts would be but a rough makeshift. Regulation by National Forests is but a single step in advance and still a very imperfect alternative. Each Forest should be divided into working circles, called Divisions, based on geography and market, and a separate working plan made for each Division.

2. Detailed material hitherto included in the body of the plan should be placed in the appendix to avoid burdening the plan and yet retain the material.

3. Forest description, hitherto overlooked, is of great silvicultural importance and should receive more careful treatment.

4. A thorough knowledge of market conditions and methods of utilization is essential.

5. Maps should be made with contours instead of hachures. Different ones are required for the different plans.

6. The silvicultural systems and marking rules are the most important parts of the working plan.

7. Some growth data applying to the region in question are necessary.

8. The regulation of the cut in uneven-aged Forests should be based on volumes with an area check; in even-aged Forests on area with a volume check.

9. The final allotment of the yield must be made with due regard to local needs.

10. Other plans forming part of the working plan should be properly correlated and made to form a homogeneous whole.

CONSERVATION AND CHEMICAL PULP

BY DR. B. HERSTEIN

Technical Expert, Tariff Board

(Contributed)

I shall confine myself in this paper to the statement of certain facts and conditions, unembellished by any discussion of a theoretical nature, however pertinent to the subject and however tempting the occasion may be. Such a problem as the conservation of natural resources is too vast and wide for more than anything but a mere presentation of the underlying causes which have brought it into existence, and is of too vital importance to permit of controversies other than those based on indisputable facts. The proposal of remedial measures, adequate and yet feasible under prevailing conditions, is the business of men who by vocation or the trust of the people have been charged with the task of maintaining the rational continuity of the resources of our national wealth and economic independence, and of those who from a praiseworthy conception of civic obligations have voluntarily taken this task upon themselves. To point to sources of useless waste, actual or potential, of the heritage of those to come is the duty of every citizen.

The manufacture of wood pulp by the so-called "sulphite process" involves a loss of practically one-half of the weight of the barked wood necessary for the operation. This condition prevails not only with the above-mentioned process, but is in greater or lesser degree a feature of all chemical processes devised for preparing paper pulp from wood. It is due to the fact that wood is far from being chemically a uniform substance, the cellulose which it contains and which alone is valuable as a paper-forming fiber being only about 50 per cent in weight, according to the kind and age of the wood. The other half of the weight is made up of a number of little-known constituents, such as resins, lignin, and other carbohydrates, etc., which incrustate the cellulose and must therefore be removed if the fiber is to be of good and lasting quality. This can be effected only by chemical methods, whereby all these undesirable substances—undesirable only in relation to the object in view—are brought more or less into solution and thus separated from the cellulose, which remains behind in insoluble form.

Two processes mainly are used for this purpose: The "soda process," consisting in boiling the wood with a solution of caustic soda under

pressure, and the "sulphite process," which uses a solution of a "bisulphite"—mostly of lime—as the solvent. Each process has its relative merits and the technique in both is similar. The organic constituents of the wood which have been dissolved by the operation and, as stated above, are practically one-half of the total weight of the wood originally employed, are, as far as the manufacture of wood fiber is concerned, an economic loss, though founded in the nature of the wood and therefore unavoidable. An adequate idea as to the quantities and the magnitude of the loss involved may be gained from the figures furnished by the census statistics of 1905, showing a production for that year of

Soda pulp	197,000	tons.
Sulphite pulp	756,000	"
Total	953,000	"

These figures, owing to the natural expansion of the industry, must now be considerably larger. The weight of the organic constituents of the wood carried off by the solvents is at least equal to the weight of the pulp made, and the economic disposal of this waste is a problem which still awaits solution.

In the case of the soda pulp a partial solution has been forced upon the manufacturer by the fact that the liquid after having acted upon the wood contains with the organic matter extracted from the wood also the valuable soda, which can be reclaimed without much cost. The solution is evaporated to a thick syrup and in this condition will burn by itself when once ignited, the organic matter present furnishing the fuel. The heat thus generated is used to evaporate a fresh portion of thin liquor. The soda left in the ash is extracted with water, causticized, and used on fresh wood.

From the comparative figures given above it can be seen that the soda pulp made is only a little over 20 per cent of the total weight of pulp manufactured; the problem of disposal of the waste liquors is therefore not of so great importance. Indeed, except for the fact that the evaporation of these liquors is accompanied by the evolution of foul gases, this method of disposal of the waste is probably commercially the best, because the manufacturer is able to use the product himself.

But no such disposal is possible in the case of sulphite fiber, because the bisulphite which the liquor carries along with organic matters cannot be reclaimed economically, and, moreover, this will not sustain combustion after concentration without extraneous fuel. The liquor, containing about 10 per cent of organic and about 1 per cent of inorganic substances, is in nearly all cases simply run into the river. This may be the most

convenient way for the manufacturer, but is certainly not in line with the public weal, for not only does the poisonous sulphurous acid which this liquid contains exert its baneful action upon anything living in the river in the vicinity of the mill, but the fine fibers which are unavoidably carried along get caught in the gills of the fish and after a while prevent their proper breathing. The fish then die from suffocation even at considerable distances from the mill. Nor is this all. The enormous quantity of organic matter thus thrown into the rivers is in its natural process of decay split up into substances injurious to animal life and of foul odor, which, unless the river carries a very large volume of water, render the vicinity of a pulp mill little desirable as a place of habitation. We are rapidly approaching the time when our rivers will be unable to absorb any more of these sulphite liquors with their enormous quantities of organic substances, and the problem of their proper disposal, looked at from this point of view, assumes additional importance. It becomes largely one of national hygiene besides being eminently economic.

In Europe, where paternal governments often exercise their functions within spheres considered here sacredly individual, the erection of chemical pulp plants and the disposal of waste liquors require the consideration and consent of the authorities charged with looking after the interests of the community at large. The manufacturer must dispose of his waste, but he must do it in a way which will not destroy nor endanger animal life or otherwise put undue burdens on the public. Propositions having this object in view have been advanced by many inventors and in great numbers, but evidently only those deserve any consideration which prepare from the liquors a product or products of mass consumption, and do this within commercially admissible limits. The proposal to evaporate the liquid and make therefrom, eventually under addition of certain chemicals, pitch or liquids adaptable for impregnating woods has failed, because the products obtained are readily washed away. The use of the liquids as tanning material finds no favor with the leather manufacturers, because they fail to tan to any extent, and other inventions so far have proved equally futile with the exception of one which is now in a fair way of realization.

This exception refers to the utilization of the sulphite waste liquors for the manufacture of alcohol. The principle involved is not new. Most of the constituents of wood either belong or are closely related to the group of substances so widely found in nature and chemically known as carbohydrates, of which a great many under the influence of acids, high temperature, and pressure are changed—hydrolyzed is the scientific term—to grape sugar. Such conditions prevail when purifying wood

fiber by the bisulphite process, and the result is that the residual liquors contain a certain proportion of sugar. This cannot be separated as such, but it can be fermented into alcohol and this in its turn can be reclaimed by rectification.

Simple as the theory of this process is, it has not found practical application before because the technical difficulties were very great and made its commercial use impossible. Under the pressure of necessity, however, these impediments seem to have been gradually overcome, and this to an extent that one of the largest plants in Sweden not only has adopted the process in its new development, but within the last year has extended it so as to work up all of its waste liquors. This plant is situated in Skutskär, Sweden, and is now producing 300,000 gallons of alcohol per year The process used is that devised by Ekström, which requires cooling and neutralizing the liquids, for which latter purpose the lime residues are used, filtration, and fermentation, followed by distillation of the alcohol made. No evaporation, and consequently only little fuel, is required, and it is claimed for the process that the liquors obtained after eliminating the alcohol are entirely innocuous and can be run into the river without danger to the community.

The alcohol made is unpalatable, because it is contaminated with wood spirits and other denaturing agents, and this, if anything, is an advantage, because it makes it available for industrial purposes only.

The minimum yield is sixty liters, or fifteen gallons, per ton of fiber produced. The manufacturing cost is not stated, but the fact that a plant which is situated at the seashore, and has therefore no difficulty in disposing of its waste liquids, has adopted the process seems *prima facie* evidence of its commercial feasibility. Assuming the same yield for the United States, this would mean over 11,000,000 gallons of industrial alcohol as corresponding to the 750,000 tons of sulphite pulp made, representing a market value of $6,000,000.

Any part of this added to the national wealth would represent a clear gain, besides the economic advantage in employing additional labor, etc. Many branches of industry would welcome such an unlooked-for source of supply of the alcohol required for their work, and our manufactures would easily absorb this additional quantity even if it were all thrown on the market. The greatest advantage, however, would be for the community at large, because it would be rid of the potential danger which is involved in the indiscriminate pollution of the rivers by the waste liquids.*

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* Experiments carried on by the Office of Public Roads, U. S. Department of Agriculture, in the use of waste sulphite liquors on roads have shown that concentrated waste sulphite liquor "may be classed as a temporary or semi-permanent dust preventive and road binder."—EDITOR.

SEED PRODUCTION AND HOW TO STUDY IT

BY RAPHAEL ZON AND C. R. TILLOTSON

(Contributed)

Introduction

Last year, when a serious attempt was made by the Forest Service to collect seed on a large scale for forestation purposes, the foresters keenly realized for the first time how little knowledge exists in this country regarding the seed production of our trees and the factors which influence it. Plans for sowing operations must necessarily depend on available seed. Unless, therefore, one can foretell with a reasonable degree of certainty the amount of seed which different species will produce at definite intervals, all such plans must naturally lack definiteness. When the forester fully understands the laws of seed production he can control and stimulate it in accordance with his needs and be complete master of the situation. Aside from the practical value of such knowledge, it is of the greatest scientific interest. Our knowledge of the life history of forest trees will be incomplete until this mysterious occurrence of seed years and the factors that influence them are fully understood. Of all the silvical problems seed production is the most difficult one to solve. This may be readily inferred from the fact that although seed production excited great interest on the part of European foresters even in the early days, and several attempts were made to penetrate into the mystery of it, little as yet is known regarding the seed production even of the few European species, especially of the factors that influence it.

The investigation of seed production of forest trees consists of four distinct problems: (1) The determination of the amount of the seed crop; (2) the determination of the periodicity of seed production; (3) the determination of the various external and internal factors which affect the amount and the periodicity of seed production, and (4) the solution of the biological problem of seed production. Each of these problems must be solved in the order indicated, since the solution of each furnishes the basis for the solution of the following ones.

The first and immediate problem is to determine the amount of seed produced by each species. This may not be as simple an undertaking as it seems. Should the seed crop be estimated ocularly or actually measured on representative trees or sample plots? If it is to be meas-

ured, what is to be taken as the unit of measure—the number of cones produced by a few individual trees, the amount of cones produced per unit of area, or the quantity of germinable seed produced by individual trees or on a given unit of area? It is essential to agree on the method of measuring the seed crop before the problem of the periodicity of seed crops can be attacked. To solve the problem of the periodicity of seed crops repeated comparable investigation of the first problem carried on for a number of years is necessary. In the solution of the third problem there enters the determination, first, of the external factors such as climate, soil, exposure, light, injury, and destruction of seed by animals and fungi, and, second, of internal factors, such as composition, age, density, and health of the stand. The solution of this complicated question, or rather of this series of complicated questions, requires systematic, parallel, and uninterrupted series of investigations, which cannot be undertaken by one individual but must be carried on by permanently organized forest experiment stations. The fourth problem, which is the final aim of all the investigation, is the most difficult of all, and requires, in addition to all other lines of work, a whole series of chemical, physiological, and anatomical investigations. The study of seed production in its entirety is thus a most difficult problem.

In this article an attempt will be made to discuss merely the methods of measuring seed crops.

Historical Review

For many years the only method of studying this problem was the statistical one—that is, the collection of information, which was not always reliable, from all possible sources as to the occurrence of seed years of certain species. In Germany, Eberts,* and later Goebel,† attempted to determine the occurrence of seed years of Scotch pine by the number of cones which passed through the drying houses. Eberts worked up material for the period 1840-1871 for southern Germany, and Goebel for the period from 1837-1884 for the vicinity of Eberswalde, Prussia. As both of these works were based exclusively on yearly records of quantities of cones, the source of which was unknown, as well as the conditions under which they were produced, they could not, of course, throw much light upon the question of the periodicity of seed years, and had, therefore, no scientific value and were of little practical importance. The data thus collected give, of course, some idea of the general amount of pine cones produced in the vicinity of the drying

* Zeitschrift für Forst- und Jagdwesen, 1875.
† Ibid, 1886.

houses; silviculturally, however, they fail to explain the periodicity and variability of the seed crops.

In 1886, Schott von Schottenstein brought together a considerable amount of data as to the seed production of white pine (*P. strobus*) in the municipal forest of the city of Frankfort. This forest is composed of a pure stand of mature white pine about 7½ acres in extent, and is leased yearly for the gathering of seed, the amount of the lease being based entirely upon the amount of seed collected. On the basis of the revenue derived therefrom during the 22 years from 1865-1886, Schott von Schottenstein attempted to determine the amount of seed production of white pine. He found that in this 22-year period there were three years in which no seed whatever was produced, three years with a very scant crop, and sixteen years during which more or less seed was produced. During this period the average annual income derived from the lease was about $135, or about $18 per acre per year. In years of exceptionally bountiful seed crops, however, the revenue was much greater; thus in 1866 it was $250; in 1876 $501; in 1884 $260, and in 1886 $455.

For this early period the phenological observations of Lauprecht, published in 1875,* on the masts of oak and beech are especially interesting. For 23 successive years, from 1850 to 1873, he observed the seed production of beech and oak in the forest district Worbis, in Saxony. Each year he recorded the weather in April and May, the date of the beginning of leafing and flowering, the character of the summer weather, the time of the hardening of the beech nuts and oak acorns, the amount of each produced, and finally the damage to the seed by insects. For the sake of comparison he also recorded the seed production of the same species in two neighboring forests. The crop was determined by him ocularly and expressed as follows:

Full seed year equals 1. (This is when all trees bear seed, and occurs only in exceptionally favorable years.)

Half seed year equals ½ of a full seed year. (In these years seed is not borne at all in some stands, and is lacking on some of the trees in other stands.)

Partial seed year equals ⅛ of full seed year. (In these years so little seed is produced that there is not enough for natural reproduction.)

Lauprecht prefaces his own observations by giving some facts in regard to seed production of oak and beech in this forest in the past. As a basis for determining the extent of these past seed crops, he made use of the archive records of the number of permits issued for pasturing

* Zeitschrift für Forst- und Jagdwesen, 1875.

swine in beech and oak forests. In this way he found for the forest district Worbis that the amount of seed corresponding to a full seed year was produced for the following definite periods at the intervals indicated: for the period from 1787-1811 every 8 years; for the period from 1834-1849 every 10 years. For the period from 1812-1833 there were no data. For the first period the author gives for beech more detailed figures, as follows:

1787, partial seed year (one-eighth).
1789, half seed year (one-half).
1794, full seed year (one).
1797, partial seed year (one-eighth).
1803, half seed year (one-half).
1804, partial seed year (one-eighth).
1808, partial seed year (one-eighth).
1811, half seed year (one-half).

Thus for the period from 1787-1811—that is, for 25 years—there were 1 full seed year, 3 half seed years, and 4 partial seed years; the remaining 17 years were entire failures. Adding up the entire amount of beech seed produced in the 25 years, it will be seen that the total amount is equivalent to 3 full seed years. By dividing 25 by 3, the interval of 8 years is obtained. In other words, in the course of 8 years an amount of seed equal to that of one full seed year is produced.

During the second period the seed years occurred in the following manner:

1834, half seed year (one-half).
1836, partial seed year (one-eighth).
1843, half seed year (one-half).
1846, partial seed year (one-eighth).

The remaining 12 years were failures.

Jacobi determined this interval in the production of beech nuts for the municipal forest of Göttingen during the same period (18th century) to be 7 years—that is, one year less than the interval determined by Lauprecht. This is undoubtedly due to the more favorable location of the Göttingen forest.

Lauprecht brought together in a tabular form all of his phenological observations to show that for the period from 1850-1873 the amount of beech nuts corresponding to a full seed year was produced only in about 12 years; in other words, seed production of beech during the years in which he made phenological observations was less abundant than in the preceding period. For the oak, Lauprecht did not determine the interval but merely indicated that there were 7 years during which acorns

were produced. The amount produced, however, was so small that he did not designate even a single one as a half seed year but placed them rather in the partial category. In conclusion, Lauprecht expressed the opinion that only experimental studies could determine thoroughly the conditions affecting seed production, since only by such studies could all the factors be carefully measured, especially the meteorological phenomena.

A more serious attempt at an investigation based upon systematic observations was made by the Prussian Central Experiment Station. These observations were carried on for 20 years in accordance with a definite plan, and were designed to obtain a solid foundation for determining the seed productivity of forest trees. The method consisted in an ocular estimate of the amount of seed produced by the dominant species in the stand. By means of a set of questions prepared by the Central Station and sent out to each government forest, information in regard to the amount of seed production on these forests was obtained through the forester in charge. This amount was designated as good (full), medium, poor, and none. These data were published each year in the "Zeitschrift für Forst- und Jagdwesen," and finally, in 1895, Professor Schwappach made a final summing up of all the data obtained during the 20 years.

At the very beginning Schwappach points out three serious drawbacks to all of these observations: (1) The same care and interest was not taken with the observations in every case, and therefore they were not uniformly accurate; (2) there was no general standard for determining the amount of seed produced, since for the different latitudes the conception of a full seed year must have been different. Lack of a common standard for determining the amount of the seed crop resulted, for instance, in one observer determining the seed production of oak by the quantity of acorns and another by their quality. The material thus obtained did not have the same uniform significance, and could not, therefore, be fairly comparable; (3) Schwappach points out that the weak side of these investigations is that in its plan the Experiment Station did not indicate to what extent a given species must be present in the stand in order that its seed production be determined. It is a well-known fact that single trees occurring here and there in a stand bear seed more frequently than pure or nearly pure stands.

The most serious defect of this work lies, however, in the fact that in making these observations on seed productivity there were not made at the same time observations on the main meteorological phenomena, and no data were collected as to the age and density of the stand, the charac-

ter of the soil, and the exposure; in other words, no data were collected as to the chief factors which affect the degree of seed production.

General conclusions drawn from such heterogeneous material can scarcely be considered trustworthy. Schwappach himself justly remarks that the averages of seed production obtained by him for entire Prussia are not applicable to individual localities, and he cautions the reader against giving too much scientific recognition to these observations. Without going into the details of Schwappach's work, there will be given here only the main conclusions to which he came in working up this enormous amount of material that accumulated during 20 years of observations.

Schwappach expressed numerically the amount of seed produced by designating a full seed year as 100, a medium as 50, a poor as 25, and a failure as 0. He determined the average seed productivity of each species by using the following formula:

$$\frac{a \times 100 + b \times 50 + c \times 25 + d \times 0}{a + b + c + d}$$

a = number of full seed years.
b = number of medium seed years.
c = number of poor seed years.
d = number of failures.

By means of this formula, Schwappach showed in the following table the average seed productivity for entire Prussia of each of the nine principal species. In addition, he used the figures 1, 2, 3, and 4 to express the relative seed productivity—1 to designate a very good seed crop and 4 a very poor one. From this table it may be seen that the average seed productivity of the different species for 20 years ranges from 16.2 per cent to 44.8 per cent of a full seed year. All the species may be arranged in the order of seed productivity as follows:

Birch	44.8 per cent.
Hornbeam	42. per cent.
Alder	39.9 per cent.
Scotch pine	37.6 per cent.
Norway spruce	37.1 per cent.
Fir (A. pectinata)	34.5 per cent.
Ash	33.3 per cent.
Oak	17.1 per cent.
Beech	16.2 per cent.

Analyzing the variation of this average seed productivity for the entire period of observation, Schwappach found that these average figures

are not subject to variation, and can therefore be considered as constant quantities for each species. He calls them coefficients of seed production. Thus on the basis of seed productivity the species under observation may be divided into three groups. In the first group are included those which bear seed most frequently, and produce every two years an amount almost equal to a full seed year—that is, 100. Birch and hornbeam belong here. To the second group belong species with medium coefficients of seed production, which bear in three years as much seed as is produced in a full seed year. Alder, pine, spruce, fir, and ash fall into this class. Finally, the third group is made up of the least seed-productive trees, oak and beech, which produce only in six years an amount of seed equal to one full seed year.

Besides the coefficient, Schwappach gives in the following table data regarding the extreme variations in seed production—that is, the maximum and minimum seed crops of individual species for entire Prussia.

TABLE 1.

Seed Production.

Year.	Oak.		Beech.		Hornbeam.		Ash.		Birch.		Alder.		Pine.		Spruce.		Fir.	
	Average.	Relative.	Average.	Relative.	Average.	Relative.	Average.	Relative.	Average.	Relative.	Average.	Relative.	Average.	Relative.	Average.	Relative.	Average.	Relative.
1874	18.6	2	12.1	3	19.5	4	28.5	3	41.0	2	37.2	3	41.9	1	50.7	1	42.6	1
1875	31.8	1	21.5	1	44.4	2	36.4	2	51.8	1	39.9	2	37.8	2	46.7	1	30.8	3
1876	6.2	4	1.6	4	29.7	3	17.6	4	33.3	3	31.9	4	29.4	3	24.0	4	21.7	4
1877	11.7	4	35.9	1	47.2	1	32.4	2	43.0	2	37.2	3	40.9	1	47.3	1	41.5	1
1878	33.7	1	0.8	4	22.5	4	28.7	3	41.3	2	36.6	3	33.7	3	37.3	2	32.0	3
1879	8.3	4	2.1	4	43.2	2	34.1	2	37.1	3	37.8	3	31.7	3	21.8	4	20.4	4
1880	10.4	4	1.4	4	19.6	4	14.9	4	29.6	3	31.7	4	33.6	3	17.6	4	24.2	4
1881	22.8	1	20.2	1	54.3	1	61.2	1	48.4	1	42.8	1	35.7	2	36.7	2	33.8	2
1882	7.5	4	32.3	1	48.8	1	23.3	4	48.3	1	41.3	3	39.8	2	39.5	1	37.0	2
1883	16.5	2	2.5	4	37.1	3	47.4	1	40.9	2	42.1	3	34.0	3	34.7	3	23.8	4
1884	10.3	4	34.1	1	48.5	1	22.6	4	53.9	1	54.5	1	46.9	1	36.4	2	51.8	1
1885	18.6	2	4.2	4	53.7	1	44.8	1	42.9	2	38.7	2	30.0	2	35.5	2	28.4	3
1886	21.1	1	15.5	2	38.8	3	29.6	3	32.9	3	43.3	1	34.7	3	50.0	1	50.3	1
1887	12.2	3	1.9	4	51.7	1	32.8	2	41.4	2	37.3	3	37.2	2	28.6	4	23.1	4
1888	14.1	3	65.6	1	51.3	1	39.3	1	53.5	1	47.7	1	41.3	1	49.2	1	48.5	1
1889	11.5	4	2.8	4	23.0	4	20.5	4	42.7	2	38.8	2	37.5	2	28.7	4	25.4	3
1890	12.7	3	32.3	1	67.7	1	29.5	3	47.3	1	46.3	3	36.3	2	60.8	1	45.5	1
1891	7.7	4	1.8	4	29.2	3	41.2	1	33.4	3	31.7	4	54.2	1	26.8	4	23.6	4
1892	36.4	1	5.3	4	26.9	4	23.1	4	46.5	2	44.9	1	40.2	1	25.1	4	33.1	2
1893	34.0	1	27.7	1	65.3	1	50.0	1	54.3	1	46.2	1	35.9	2	40.5	1	44.4	1

TABLE 2.

Species.	Maximum.		Minimum.		Difference between maximum and minimum.
	Year.	Seed production.	Year.	Seed production.	
Oak	1892	36.4	1876	6.2	30.2
Beech	1888	65.5	1878	0.8	64.7
Hornbeam ...	1890	67.7	1877	19.5	48.2
Ash	1881	61.2	1880	14.9	46.3
Birch	1893	54.3	1880	29.6	24.7
Alder	1884	54.5	1880–91	37.7	22.8
Pine	1891	54.2	1876	29.4	24.8
Spruce	1890	60.8	1879	21.8	39.0
Fir	1884	51.8	1879	20.4	31.4

From Table 2 it will be seen that the greatest variation in seed productivity of different years for entire Prussia is observed in beech—64.7 per cent. In poor seed years this species throughout Prussia produces a very small quantity of seed—an amount equal to only about 0.8 per cent of a full seed year. Of the other species, oak comes closest in this respect to beech. In alder, birch, and pine these variations are the least (alder 22.8 per cent, birch 24.4 per cent, pine 24.8 per cent). The amount of seed produced by these species, even in a poor seed year, for entire Prussia is still considerable—namely, about one-third of a full seed year. That means that these species, while failing to produce seed in one locality, do produce abundant seed in some other locality during the same year. In the case of oak and beech, however, the low seed production means that there is a general failure of most of these species throughout the entire country. All other species occupy an intermediate place between these two extremes.

Since these coefficients are average figures of the seed productivity of the different species for entire Prussia, they do not enable one to judge as to the seed production in any individual locality. In order to determine the seed production of species for a given locality, Schwappach divided the 29 forest districts over which the observations extended into four groups, in accordance with the average seed production of each district. These groups are made up as follows:

GROUP 1. Those districts in which there is a very good seed production of one species.

GROUP 2. Those districts in which there is a good seed production of one species.

GROUP 3. Those districts in which there is a medium seed production of one species.

GROUP 4. Those districts in which there is a poor seed production of one species.

Then he selected for each group and species a district typical of a given province of Prussia, and compared how the average seed productivity of the district varied by years with the geographical location of the place. In this way he succeeded in showing that oak in Hanover, for instance, during 20 years had eight very good seed years (1875-78-81-83-85-86-92-93), five good seed years (1874-77-82-88-90), one medium seed year (1887), and six poor seed years (1876-79-80-84-89-91), which makes an average seed production of 21.7, whereas in Dantzig during the same time oak had only three very good seed years (1887-92-93), four good seed years (1874-76-79-90), five medium seed years (1881-83-85-86-88), and eight poor ones (1874-75-78-80-82-84-89-91). This gives an average seed production of 11.6 per cent, or one-half that of Hanover, a more southern district. In the same way he determined the influence of individual localities upon the seed production of other secies.

Finally, in describing each species separately, Schwappach gives figures of seed production for individual forests. Thus, for instance, with oak he took one forest for each group of the districts, and found the following number of seed crops of different degrees of abundance:

TABLE 3.

Name of Forest and Number of Group.

	Walsrode (I)	Coblenz (II)	Neuhaus (III)	Gnewau (IV)
Full seed year	4	..	..	..
Half seed year	4	3	1	1
Partial seed year	8	8	7	6
Failure	4	9	12	13

These data are perhaps of the greatest interest, since they refer to comparatively small areas several thousand acres in extent, with more or less uniform soil and climatic conditions; yet even these figures have only a relative value, since there is no assurance that these results were obtained in stands similar as to age, composition, density, and exposure. The remarkable and impartial analysis by Professor Schwappach of the vast material yielded, of course, interesting general conclusions regarding seed productivity of nine species. On account, however, of the unscientific method of gathering the data and their extreme heterogeneity, this

enormous undertaking of the Prussian Experiment Station advanced the question of seed production very little. It proved, however, the need of another method of investigation—namely, that of accurate experimental research. Geyer gave an appropriate estimate of this work when he said: "In attempting such general conclusions regarding seed production over large areas, it is impossible to solve the physiological problem of the periodicity of seed years, because the age, the soil, the character of the stand, etc., are not taken into account in such conclusions."

Two years after Schwappach's work, Professor Wimmenauer, of Giessen University, published the main results of ten years' forest phenological observations in Germany for the period between 1885 and 1894. These observations were made in accordance with a program worked out and approved by the Union of German Experiment Stations. In this work, from 218 to 260 experiment stations, which were distributed over Germany in the following manner, took part each year:

Baden	from	21–23	stations.
Braunschsveig	from	10–16	stations.
Alsace-Lorraine	from	18–20	stations.
Grand Dukedom Hesse	from	32–45	stations.
Prussia	from	100–105	stations.
Thüringen	from	14–32	stations.
Würtemburg	from	3–35	stations.

In this plan observations upon the chief phases of development of those plants and animals which play any part in forest or farm management were included. The seed production was determined for mature trees selected by each station for daily observations and the degree of seed productivity was expressed by the words prolific, fair, and poor. Besides this, notes were made only as to whether all or only a few individuals were bearing seed. Together with these observations, each station supplied brief meteorological facts which affected more or less the development and maturing of the seed (for instance, the occurrence of late or early frosts). The observations covered thirteen principal forest trees. Computing the data which were obtained during these ten years of observations, Wimmenauer, like Schwappach, gave a numerical expression for the three degrees of seed production, designating the prolific bearing or full seed year as 1, the fair seed year as $\frac{2}{3}$, the poor seed year as $\frac{1}{3}$, and finally the failure as 0. The determination of the average seed production of each year for the different species was obtained in the following manner: the total number of stations which reported seed crops were divided into four groups in accordance with the amount of seed produced, and each of these four figures were multiplied by its coefficient

of seed production—namely, 1, ⅔, ⅓, or 0. The number of stations of each class was expressed as a per cent of the total. The sum of these products expressed the average seed production of the whole region; thus, for instance, in 1885 the following reports were made regarding the seed production of Norway spruce:

12 per cent of all the stations reported a full seed year.
32 per cent of all the stations reported a fair seed year.
47 per cent of all the stations reported a poor seed year.
9 per cent of all the stations reported a complete failure.

Multiply these figures by their corresponding coefficient, we arrive at the following results:

$$0.12 \times 1 = 0.12$$
$$0.32 \times \tfrac{2}{3} = 0.213$$
$$0.47 \times \tfrac{1}{3} = 0.157$$
$$0.09 \times 0 = 0.0$$
$$\text{Total} = 0.490$$

Thus in 1885 the average seed production of spruce for the entire region was equal to 0.49—that is, almost one-half of a full seed year. This is the average seed production for one year. In order to obtain the average for the ten-year period it is necessary to add the average seed productions for each of the ten years and divide the sum by ten. By means of such computation Wimmenauer obtained the following figures, which express the average seed production for all stations at which the observations were made:

Average Seed Production.

No.	Species.	Maximum.	Minimum.	Average.	According to Schwappach for Prussia.
1	Beech	0.90	0.02	0.25	0.16
2	Oak	0.64	0.13	0.29	0.17
3	White pine	0.56	0.15	0.29	....
4	Larch	0.45	0.18	0.31	....
5	Elm	0.59	0.24	0.38	....
6	Scotch pine	0.50	0.30	0.39	0.38
7	Silver fir	0.63	0.16	0.39	0.35
8	Norway and sycamore maples	0.75	0.20	0.44	....
9	Norway spruce	0.60	0.23	0.45	0.37
10	Ash	0.63	0.24	0.46	0.33
11	Alder	0.61	0.38	0.50	0.40
12	Birch	0.71	0.37	0.54	0.45
13	Hornbeam	0.79	0.26	0.54	0.42

The thirteen species are arranged in the order of seed production. We see that beech and oak bear the least seed and birch and hornbeam the most. The range of extremes is greatest in beech and oak; thus in 1888 beech almost everywhere produced a full seed crop—90 per cent; in 1891 the average seed production fell to the minimum—2 per cent. The seed production of oak ranges within considerably smaller limits, and even in the poorest seed years does not fall below 0.13 of a full seed year. This shows that each year in the region under consideration oak produces here and there considerable mast.

Comparing the average seed production obtained by Wimmenauer's observations with that computed by Schwappach, we find for most of the species a complete analogy. The only difference is that Wimmenauer's coefficients of seed production are considerably higher than those computed by Schwappach. This, however, is to be expected, since Schwappach's observations cover Prussia only, while those of Wimmenauer include also the southern part of Germany.

These works of the Prussian and the Southern Germany Experiment Stations complete the first cycle in the history of the question of seed production. This period of observation which is characterized by the accumulation of fragmentary data regarding seed production or of statistical data concerning whole regions did not establish any accurate facts which would throw light upon the nature of this complicated process in the life of the forest.

In 1881, a year of exceptional seed production, Kienitz* actually counted on three pines which stood by themselves, and on 42 other trees which formed a stand of about one-sixth of an acre, the number of cones, and even determined the amount of seed in them. This little investigation, while it stands by itself, marks a new departure in the study of seed production.

The credit, however, for approaching the problem in a thoroughly scientific manner belongs to Russian foresters, especially Ogievsky and Sobichevsky. Ogievsky was the first to introduce a new method of studying this problem. In 1895 he undertook systematic investigations of the seed production of Scotch pine in the central provinces of Russia. The object of his investigation was to determine how often and how large were the seed crops of Scotch pine and what factors determine its seed production. The method of investigation consisted in actually counting the one and two year old cones of Scotch pine on five intermediate trees (Class III—Kraft's classification). As a result of this investigation he obtained the average number of two-year-old cones per tree, and advanced

* Zeitschrift für Forst- und Jagdwesen, 1881.

the theory of the direct relation between seed crops and precipitation. Ogievsky, however, studied the seed production of individual trees, and not of whole stands. Furthermore, his method consisted in counting the number of cones, and not in determining the quantity of germinable seed. Several other Russian foresters have attempted the study of seed production along the lines indicated by Ogievsky. A really scientific plan, however, for this study has been made out by Sobichevsky, professor of the St. Petersburg Forest Institute.

The Method of Investigation

In the study of seed production the first thing to determine is the standard by which to measure the seed crop from year to year. The periodicity of seed crops cannot be established unless there is an accurate standard for measuring seed production. The production of seed in forest trees is not a function of an individual tree, but is really the function of the whole stand, since the development and the life processes of each tree in the stand is determined by the density, composition, and age of the stand and by the position of the tree in the stand. Therefore, in determining the amount of the seed crop, the quantity of seed produced per unit of area and not the amount produced by individual trees should be made the basis of measurement. Further, the cone production cannot alone serve as a basis for measuring the seed crop. The seed production must be measured not by the quantity of cones but by the amount of seed produced, because the final aim in the study of seed crops is not the cones but the seed. The quantity of seed, therefore, viz., its germinability, must be taken into consideration. Two stands may produce on an average different quantities of cones per tree, yet the stand in which the average number of cones per tree is the smaller may furnish more germinable seed than the stand in which the average number of cones per tree is the larger. Ungerminable seed are biologically nothing but impurities, and it would therefore be a mistake not to leave them out of consideration in determining the amount of seed production. Thus in the determinatioin of seed crops there enter three conditions: (1) The determination of seed production for the stand per unit of area and not for individual trees; (2) the determination of the quantity of seed, and (3) the determination of the principal quality—germinability. The weight of germinable seed per unit of area must be accepted as the standard for measuring seed crops. If "a" is the weight of pure air-dried seed obtained from one acre and "p" is their germination per cent, then the seed crop, or "x," may be expressed by the formula "$x = ap$."

Since the aim is to determine the amount of seed produced per certain unit of area, the best method of studying seed production is by means of sample areas. These areas may be from one-quarter of an acre to one-half of an acre in extent, in accordance with the number of trees per acre. Each sample area, however, should include at least 100 trees of the principal species composing the stand.

It would, of course, be more accurate to gather cones and obtain the seed from all of the trees on the sample area. This, however, would necessitate the cutting down of the trees, which is not always practicable nor possible. Moreover, this operation would require a great deal of time, which would make such an investigation difficult. For this reason it is preferable to collect the cones and extract the seed only from sample trees.

It is a well-established fact that light is a necessary condition for seed production, and daily observations show that the greater the amount of light received by the tree the more developed is its crown and the greater is the amount of seed produced by it. It may be already accepted *a priori* that individual trees in a stand do not produce equal amounts of seed, but vary in accordance with their crown development. For this reason it is necessary to select the sample trees in a special manner most suitable for the purpose of this investigation. In the selection of the sample trees one must be guided by the form and development of the crown of the individual tree. In the different species the different parts of the crown have varying importance; thus in spruce the upper part of the crown is of the most importance, since it is there that the largest number of cones are developed; in other species it may be the extremities of the largest lower branches.

In order that the amount of seed obtained from the sample trees should, when multiplied by the total number of trees on the sample plot, actually represent the amount produced on the sample plot, the sample trees must include representatives of all groups of trees which differ in any way in their crown development. With this end in view, all the trees on the sample plot are tallied, their diameters measured, and they are divided into groups in accordance with their crown development. From these groups the sample trees are selected. As a basis for dividing the trees into groups in accordance with their crown development the ordinary classification of trees into dominant (I), codominant (II), intermediate (III), oppressed (IV), and suppressed (V) may be accepted. Since, however, codominant and intermediate trees may still differ greatly in crown development, these two classes may be further subdivided and designated by the letters *a, b, c,* and *d.* In this way there may be from

seven to ten classes or groups of trees, each group including trees which appear to have a more or less uniform crown development.

At the time the trees are measured and divided into groups notes are made on each one as to whether or not it is bearing cones. These data, which are very interesting in themselves, become absolutely essential in case of partial seed production, when not all of the trees bear cones. The division of trees into groups, with notes regarding the presence or absence of cones on them, forms the most difficult and tedious part of the work in laying out such sample plots. The investigator must very carefully look over each crown from all sides and must distinctly keep the habitus of the crown in mind so that he can place it in the right group. This work is especially difficult in laying out the first sample plot, but after some practice, when the observer has clearly impressed upon his mind the typical forms of crowns which occur most frequently in stands of the same species, his work becomes much easier. Experience has taught that in order to avoid errors in dividing the trees into groups the total number on the sample plot must not exceed 100. The size of the sample plot will depend, therefore, upon the age, density, and composition of the stand.

The enumeration of the trees may be made by marking each tree with white paper tags and the record kept on a form similar to the one given below:

No.	Diameter, inches.	Class.	Cones. Present + Absent —
1..................................	25	III*a*	+
1..................................	13	V	—
Aspen..............................	27		

When in a mixed stand a tree of secondary species occurs its name should be given in the first column, but columns 3 and 4 left blank. When all the trees are tallied, the number in each class is computed and from each class sample trees are selected. The per cent of sample trees to the total number of trees must be decided beforehand. For ordinary investigations 10 per cent of the total number of trees on the sample plot may be sufficient. For more intensive investigations, however, a larger per cent of sample trees should be taken. This, of course, will considerably increase all subsequent computations.

The more carefully the division into classes is done and the more uniform the crowns of each class the easier it is to select the sample trees. To facilitate the work it is advisable to select sample trees separately for each class—that is, first to look over the trees—for instance of Class I, and select sample trees for this class, then take up the next class of trees, and so on.

When not all trees in the stand are bearing cones, the ones which do bear cones are selected as sample trees, and, in determining the amount of seed production, the per cent of seed-bearing trees for each group is taken into account.

The sample trees are felled, care being taken in felling them that they do not touch the crowns of other trees and thus knock off their own cones or those of other trees. From the felled sample trees all the cones are gathered very carefully, those which still hang on the branches as well as those which were knocked off in felling the tree. It is necessary to avoid collecting cones which were knocked off from other trees. This can often be very readily accomplished, since the cones of each tree differ in size and form, a fact which is especially true in the case of spruce. The cones gathered from each sample tree are put in separate sacks, properly labeled, and after being slightly dried at an ordinary room temperature are subjected to further investigation.

The total height, age, and health of each of the sample trees is determined, the number of cones from each counted, their length measured, and their volume and green weight determined. The cones are then dried and the seed extracted. Coniferous tree seed are separated from their wings, cleaned, and weighed. If there is any foreign matter present its per cent is determined by weighing several grams of the sample, then cleaning it of all foreign matter and reweighing. The difference between the two weights is used to calculate the per cent of foreign matter by weight in the sample. After the seed are cleaned, 200 are taken, their weight determined to 1/100 of a gram, and are then subjected to a germination test. After the germination per cent is determined, all data necessary for determining the amount of seed per unit of area—for instance, an acre—are at hand by means of the formula "$x = ap$." The following are forms for keeping a record of all the data and the final results obtained. These tables at the same time indicate the different consecutive stages in the study of seed production and furnish, so far as we know, the first comprehensive plan for measuring the seed crop. The measurement of the seed crop, as has already been pointed out, lies at the foundation of the entire problem of seed production.

TABLE A.—THE SAMPLE PLOT.

Area = 7/10 Acre.

Diameter, inches.	The number of trees.					Classification of spruce.									
						According to crown, classes.						According to presence or absence of cones.			
												With cones.		Without cones.	
	Spruce.					I	II	III	IVa	IVb	Va	No.	Per cent.	No.	Per cent.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
3–4	1	..	..	..	..	..	..	..	..	..	1	..	..	1	100
4–6	29	..	..	..	..	..	..	..	12	8	9	13	45	16	55
6–8	39	..	..	..	..	..	..	18	19	2	..	29	74	10	26
8–10	27	..	..	..	..	..	7	18	2	..	..	22	81	3	19
10–12	6	..	..	..	..	..	6	..	..	..	..	6	100	..	..
12–14	2	..	..	..	..	..	2	..	..	..	..	2	100	..	..
14–16	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
16–18	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total	104	..	..	..	..	..	15	36	33	10	10	72	71	30	29
Per cent	100	..	..	..	..	..	15	35	32	9	9	..	..	..	..
Number of spruce with cones, in per cent							100	100	77	0	0	..	..	..	..

TABLE B.—THE SAMPLE TREES.

Description of the trees.				Description of the cones.										Description of the seed.				
Diameter, inches.	Crown, class.	Age, years.	Height, feet.	Number of cones according to length in inches.						Total.	Average length of a cone, inches.	Total weight, pounds.	Total volume, cu. ft.	Weight of cleaned seed, ounces.	Weight of 200 seed, ounces.	Germination, per cent.	Period of rest.	Average number of seed per cone.
				2–2.4	2.4–3.2	3.2–4	4–4.8	4.8–5.6	5.6–6.4									
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
12.4......	II	194	75.4	37	186	145	7	..	..	375	3.1	?	4.59	4.8	.032	64	9	81
10.4......		162	59.0															
8.8......		159	68.9															
8.8......	III	160	59.0	15	62	24	..	..	..	101	2.9	?	1.77	1.7	.035	86	10	97
8.8......		150	59.0															
7.2......		150	59.0															
7.2......		160	59.0															
8.8......	IVa	15[illegible]	55.8	9	60	37	..	..	..	106	3.0	?	1.77	1.3	.026	53	9	99
7.2......		156	52.5															
7.2......		156	52.5															
5.2......		156	45.9															
5.2........	IVb	153	42.6	..	4	..	..	..	..	4	2.8	?	.11	.009?	.024	25	13	?
5.2........	Va	144	42.6	..	4	..	..	..	..	...	...	?	....	.....	....	..	..	..
Total....	......	......	......	61	312	206	7	..	..	586	...	?	8.24	7.809	....	..	..	..

TABLE C.—THE SEED CROP.

Crown, class.	Data in regard to the sample plot.						Amount of seed produced per acre.					
	Total number of trees.		Total number of sample trees.		Yield of sample trees.		Amount of cones.		Amount of seed.		Seed production according to the formula "V=ap."	
	No.	Per cent.	No.	Per cent.	Cones, cu. ft.	Seed, ounces.	Cu. ft.	Per cent.	Ounces.	Per cent.	Ounces.	Per cent.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
II	15	15	3	20	4.59	4.8	8.44	42	88.9	48	56.9	45
III	36	35	4	11	1.77	1.7	5.86	30	56.0	30	48.2	38
IV*a*.........	33	32	4	12	1.77	1.3	5.19	26	40.7	22	21.6	17
IV*b*.........	10	9	1	10	.11	.009	.39	2	?	...	.....	...
V*a*.........	10	9	1	10	....	.....	.....	...	.....	...	.....	...
Total..	104	100	13	12	8.24	7.809	19.88	100	185.6	100	126.7	100

BETTER METHODS OF FIRE CONTROL

BY W. B. GREELEY

(Contributed)

The general fire-protection organization of the Forest Service is so well understood that it is unnecessary to attempt a comprehensive description of its field force and methods. It will be of greater value to discuss a few specific points which have been emphasized by personal experience and which may indicate some ways in which the present fire-control system of the Service can be strengthened. These have been grouped, for convenience, under headings which are somewhat descriptive of the relation of the suggestions offered to the entire scheme of fire protection.

Patrol

The patrol force which each National Forest should carry, and its intensity as between different Forests, must be determined by a close analysis (1) of the relative values of the property at stake and (2) of the relative fire hazard. A calculation of the relative values of the property to be protected is fundamental to an intelligent distribution of the patrol force. Obviously a fire in brush or grass lands is of insignificant importance as compared with one in heavy stands of timber. A distinction less frequently considered is the relative value of different stands of timber and of stands of immature or young growth in relatively accessible locations as against over-ripe stands in such inaccessible districts that their utilization during the period of merchantability is questionable.

The calculation of relative fire hazard is analogous to the rating of insurance premiums on various classes of city property, and should be no less exhaustive. It must consider not only the comparative risk on different Forest areas due to local causes of fire, but also the relative inflammability of the various forest types, the amount of inflammable material on the ground, the presence or absence of natural fire-breaks, the conditions as to ease of access and travel, and ease or difficulty in securing emergency help.

An analysis of relative values and relative fire hazard in District 1 has resulted in the assignment of patrolmen to the open Forests east of the Continental Divide in central Montana and to the denser Forests of western Montana and northern Idaho, in the general ratio of 1 to 3. Provision was first made for all purely administrative work on the re-

spective Forests on the basis of the number of days of ranger labor required to handle current timber sales, grazing, lands work, and other business, and the remaining funds allotted for patrol on the basis of acreage. It was then possible to use approximately 50,000 acres as the patrol unit west of the Divide for the four months' fire season, and approximately 150,000 acres as the unit on the more open Forests, with less valuable stands of timber, east of the Divide.

On the individual Forest, the most essential point is the careful placing of the patrolmen available in reference to the relative fire danger. A close analysis of the causes and location of fires during preceding seasons is necessary to this end. In District 1, for example, with 86 per cent of all fires during the summer of 1910 originating along railroad tracks, it is obvious that an intensive railroad patrol is the first essential. This was maintained on the basis of one patrolman for every three to fifteen miles of track, depending upon the amount of traffic, the grade, and condition of the right of way. Nearly all of the railway patrolmen were equipped with velocipede or bicycle speeders, carrying a shovel, axe, mattock, and collapsible canvas bucket. As conditions became more serious last summer, it became necessary in many localities to increase the railway patrol to a point where every individual train could be followed. The wisdom of a railway patrol so intensive in character was demonstrated by the season's showing of over 95 per cent of the 1,300 railway fires extinguished without damage. No other expenditure for protection work netted an equal return in actual results.

Next to fires which originate from one cause or another along railway tracks, the causes of fires which should be considered in the location and organization of patrol may be grouped into two main classes. The first are fires originating in and near settlements from slash burning, logging operations, saw-mills and the like, which can, as a rule, be most effectively guarded against by a patrol of the valleys following well-defined beats. The second class consists of fires originating in the higher and less accessible country, from lightning, campers, and the like. Patrol as a protection against such fires can usually be conducted most effectively from a system of correlated lookout points.

Taking the typical National Forest in the northern Rockies, the most practicable patrol system which has been developed as a result of cumulative experience is a combination of—

1. Very intensive patrol of railway tracks.
2. Beat patrol of settled valleys and localities in which timber operations are being conducted, and
3. Lookout patrol along the higher points in the interior districts.

Any patrol organization must be sufficiently flexible to make possible prompt adaptation to an emergency or to changed conditions which may occur during the season. A few fires may make the atmosphere so smoky that nothing can be accomplished from lookout points, and all available men can be used to best advantage in patrolling valleys or other definite beats. Concentration of the patrol force in certain localities which prove to be of peculiar danger often becomes necessary. A quick expansion in the patrol force to meet the emergency arising from continued fire danger of an exceptional character should be possible. All of these things should be provided for as far as possible—first, in the organization of the patrol force by definite districts and the giving of adequate authority to the district ranger to adapt the patrol conducted by his men to the changing exigencies of the season; and, second, by providing a reserve patrol force which can be swung into action when emergency requires. This is discussed under "Emergency Help."

My experience has shown that a patrol force which seems adequate on paper is often insufficient in the field as a fire-preventing organization, due usually to two causes: The first is the diversion of patrolmen to administrative work under the pressure to which supervisors are often subjected to keep pace with an increasing volume of timber sales, uses, or settlements with a limited force. This is a situation which can be met only by very careful study of the administrative needs of the Forest during all seasons of the year and a close holding of expenditures for the administrative force down to the actual needs of the Forest at all seasons, so as to provide funds during the fire months for an adequate patrol force which will form the foundation of the whole protection system and whose strength will at no time be impaired by drafts for administrative work. The second common defect is the frequent breaking of the continuity of the patrol by the fact that when patrolmen individually subsist themselves they must leave their districts from time to time to procure supplies. While this condition can be and has been met by many supervisors through reasonable restrictions as to the amount of the supplies which each patrolman is required to procure at one time, particularly at the beginning of the season, frequency of absences from the lookout point or district and the conditions under which they will be permitted, I believe that the system is fundamentally wrong as a basis for the most efficient type of patrol organization. The remedy which I suggest is the appointment of patrolmen with subsistence furnished by the Government, the men to be stationed at the points where needed without break during the fire season, and food supplies purchased

by the Service in bulk under the most favorable conditions as regards competition, and distributed to patrol stations by a Service pack train if needed. The fundamental advantage of this plan is that it keeps the patrolmen always on tha job; the man whom the fire plan shows to be on a certain ridge is actually on that ridge the morning after a bad lightning storm, not at a foothill settlement forty miles away rustling grub.

Communication

It is unnecessary to dwell upon the general inadequacy of the trail and telephone systems at present completed on the National Forests. In the heavily timbered portions of District 1 we have today in the average township 3.6 miles of completed trails and .6 mile of completed telephone lines. The annual increase in the mileage of trails per township under permanent improvement appropriations is 1.2, of telephone lines 1.75; and all this in a region where a large proportion of the National Forests are very inaccessible from railroads and settlements. What this actually means in the protection of densely-forested districts is readily apparent to any one familiar with the habits of a forest fire in a wilderness beyond the restraints of law or society. It took a ranger, traveling on foot last summer with a pack on his back, two days to reach one of the lightning fires near the Bitterroot Divide from the time when he sighted it. It was then beyond his control. Two days were required to reach the nearest settlement, one day in getting men, tools, supplies, and pack train together, and four days in opening the simplest and roughest kind of a trail to get the outfit in to the fire—nine days' start for the fire, although discovered within probably three hours after its inception, after a five-month drought, and with a high wind blowing every other afternoon!

In view of the inadequacy of our present trails and telephone lines, the general policy which seems to me advisable is to first establish a preliminary system of communication by the construction of rough trails, rather than *standard* trails, and by the laying of light portable telephone wires, rather than the erection of permanent pole lines. Trails of this character should be carefully located, so that the route will be permanent, but only an absolute minimum amount of work done in clearing and grading to make them passable for pack animals. In the heavily timbered areas of District 1 this means a cost of $25 to $40 per mile, or one-third of the cost of a standard trail. Such "shotgun" trails may provoke the wrath of the tourist or inspector, but this policy is, in my judgment, essential until a primary communication system has given

us a grip upon the fire situation much stronger than we now hold. Thereafter, wherever future traffic and administrative needs require, such trails can be gradually improved and brought up to standard.

The type of telephone equipment which, in my judgment, is best adapted to our immediate needs is about a No. 20 B. & S. gauge copper wire with a light insulation, similar to that used by the Signal Corps of the army. This wire should weigh not over twenty-five pounds to the mile, and should be sufficiently flexible to be readily unreeled, laid on the ground, and reeled again when desirable. Its resistance should be low enough to render it serviceable up to seventy-five or eighty miles, either as a separate grounded system or when attached to a galvanized iron pole line. Such a wire can be laid directly on the ground, establishing a very cheap and rapid means of communication from lookout stations, reporting stations on patrol routes, ranger camps, and the like. It can be similarly used to connect a fire camp with the nearest base of supplies or telephone line, resulting in much better control of the fire campaign by the Supervisor or district ranger, and in greater efficiency in the actual work done. Standard telephone instruments can be used with this wire, but a portable instrument somewhat lighter and more compact than the present test set in use by the Service would be extremely desirable. Experiments are now under way to develop the best practicable instrument of this character for our use.

Transportation

In my judgment, a well-organized system of transportation, either owned by the Service or under its direct control, is just as essential a part of an effective fire-fighting machine as a strong patrol force or a well-developed system of communication. In inaccessible regions, particularly where horses are difficult to secure in an emergency and where hired stock at best is a scarcity, a thoroughly effective fire controlling and fighting organization is impossible without a transportation system always available for throwing into use the moment it is needed. This belief has been emphasized by certain bitter experiences of my own and of my associates in which organized attacks upon bad fires have been delayed two or three, or even four, days of frantic searching for four or five pack horses. This difficulty is a very present one in the western portion of District 1, which is a region of timber and lumbering, not of stock ranches, and where, in consequence, pack horses have been exceedingly difficult to obtain on short notice. My District, with its one hundred and thirteen horses, has been accused of going into the livestock business, and has even been classified as a Class B owner under

the grazing regulations. The ownership, however, of permanent pack trains on such Forests as the Flathead, Clearwater, and Kaniksu—trains of from four to twelve horses each on different portions of these Forests, used regularly on improvement work and to supply the patrol force with subsistence, but available for fire work whenever needed—has been found to be the only practicable solution of our problem.

We cannot, of course, maintain a transportation system equal to exceptional emergencies such as that which confronted the District last summer. As the serious fire situation developed in July and August, one of the greatest difficulties encountered in effective attacks upon the large fires was in securing adequate transportation facilities. I had agents scouring the country in every direction, and brought over three hundred pack horses into service. Toward the end of the season an additional two hundred horses were held in pasture near Missoula, to be drawn upon as the latest exigencies might require. While it would be out of the question to maintain a pack-train system which could cope with a repetition of the emergency of 1910, it is my belief that each Forest in the inaccessible districts where the securing of local animals is extremely difficult should have a pack train equal to any ordinary fire season.

Emergency Help

The problem of emergency help is, in my experience, the hardest of all to solve satisfactorily in building up an efficient fire organization. Emergency help is needed for additional patrolmen whenever exceptional conditions bring about a much larger number of incipient fires than usual, for crew foremen competent to direct bodies of fire fighters when the number of fires to be fought makes it impossible to place an experienced Forest ranger in charge of each crew, and for fire fighters to do the grilling work with mattock and shovel. The latter, in my experience, has been the easiest to secure. The serious problem in a bad fire situation is to get competent men to strengthen the patrol force and direct the fire-fighting crews. The situation which developed in District 1 last season was most critical in this respect. Owing to the previous drought and frequent high winds, incipient fires were starting all over the District at a rate which baffled all previous experience and the capacity of a patrol force which had been fairly adequate during the two preceding seasons. More large fires were getting beyond control every day, and had to be fought with organized crews, often three or four distinct crews being needed on each fire. At one time there were seventeen large fires on the Cabinet Forest, with from two to four crews at work on each. There were over twenty large fires for a considerable

period on the Cœur d'Alene. Men had to be drawn from the patrol force to direct the fire-fighting crews, and yet that meant a dangerous weakening of the patrol organization. At the same time the placing of inexperienced men in charge of fire-fighting crews was almost equally dangerous.

To meet this situation three general lines of action have been worked out in District 1, at least two of which are common to all of the National Forest Districts. These are the transfer of rangers to critical areas from Forests where the danger is less acute; the correlation of improvement and reconnaissance work with the protection organization by locating improvement and reconnaissance crews, as far as practicable, in the more dangerous districts during the fire season, and the appointment of local Forest guards on a per diem basis, to be used only in emergency and paid for the time actually engaged on patrol or fire-fighting work. The last named plan is a departure from the present fire-fighting organization of the Service which appears to me to promise a tremendous strengthening of our efficiency. Under it per diem guards would be appointed from the better class of settlers, logging contractors, and mine foremen—any local residents whose occupation keeps them in or near National Forest areas. These men should perform auxiliary fire patrol at all times, putting out any fires which they discover or reporting them to the District officer, and receiving remuneration for any time actually spent in such duties. They should be swung into action in an emergency to strengthen the regular patrol or to take charge of fire-fighting crews. As far as practicable, men should be selected—such as logging contractors or mine or ranch foremen—who control other men and can thus furnish fire crews immediately if needed. In this way I believe it will be possible to build up a reserve fire-fighting and patrol force consisting of men many of whom could not, because of more remunerative employment elsewhere, be employed regularly as Forest guards, but who are willing to associate themselves with the Forest Service in an emergency for help in this capacity. This may not be the final solution of the problem, but it is clear to me that the greatest need of the Service in perfecting its fire-fighting organization is some such scheme, as nearly automatic as possible, under which an adequate force of competent and reliable men can be swung into line for short periods of critical emergency.

For temporary help in fighting fires where large crews are needed, I believe that serious consideration should be given by the Government to the use of Federal troops as a reserve force. My experience during the past summer demonstrated that the regular soldiers make good fire

fighters if they are made to feel that such work is a duty for which they are responsible and if they are given proper instruction and encouragement. My suggestion, in brief, is that a number of temporary outposts be established during the summer months at points within the National Forests where the troops will be readily accessible to a considerable area and especially where other forms of emergency help are hard to secure. A small force of soldiers should be stationed at each of these outposts, retaining their regular military organization and officered by their regular superiors. During the season their detail at these outposts should be similar in its features to similar details now made by the army at established posts, including whatever military maneuvers, target practice, or other training is deemed expedient by the officers in charge. The officer in charge should, however, be under standing orders to furnish men up to the full number of his command whenever requested by the Forest supervisor or other authorized representative of the Service for assistance during fire emergencies. This would be usually in the form of actual fire fighting, but might take the form of additional patrol if advisable under local conditions. Under some plan similar in its general features I believe that it is possible both to materially strengthen the fire organization of the Forest Service and also to give the troops training in handling themselves in the mountains, which would be of value from a purely military standpoint.

Otherwise the only suggestion I have to offer on the employment of laborers for fire fighting is the desirability, when it is realized that a bad situation which will require the continuous employment of large numbers of men is on hand, of stationing Forest officers at the available labor centers to do nothing but get in touch with employment agencies and other channels for securing help, select men, and furnish crews of the size desired upon requests from the supervisors who can best be supplied from that point. The situation which developed in District 1 last summer quickly exhausted the customary local sources of temporary help. Toward the end of the season we had to keep over three thousand temporary men continuously employed on the various fire crews. I early found it necessary to station representatives of the Forest Service at Butte and Spokane, besides Missoula and Kalispell, to do nothing but line up men and food and tool supplies and fill orders received from the various supervisors. I found that by keeping agents of the Service continually at such points it was not only possible to secure men much more quickly than could otherwise be done, but also to secure a better class of men by getting in touch with the channels where the best type of workmen for our business could be secured.

Equipment

The use of chemical apparatus and other specialized equipment and the development of a fire-break system are matters which I believe merit exhaustive study and experiment by the Service. I will not attempt to discuss them, since I have had no personal experience with either. One suggestion only will be offered. The purchase of wholesale quantities of staple food supplies in advance of the season and their storage at strategic points is, in my judgment, a very effective means of bettering the efficiency and economy of the fire-fighting organization of the Service. The purchase of food supplies for large fire-fighting crews in haste is always costly and usually involves delay in the organized attack upon the fire. If reasonable quantities of suitable supplies are purchased and stored at accessible points before the season begins, the delay is avoided and a saving of from ten to fifteen per cent on the cost of the goods effected under the much more advantageous terms which can be secured by competition. This was clearly demonstrated in District 1 last summer, where a saving of twenty cents per day in the cost of subsisting each fire-fighting employee was effected on one of the National Forests as compared with other Forests in the same locality, by the purchase of quantities of food supplies in advance of the season.

To put this plan upon the most rational basis I believe that it should be combined with the employment of a considerable number of Forest officers with subsistence furnished by the Government and a proportionate reduction in salary. Staple foodstuffs sufficient to subsist the men employed under these conditions during the season can then be purchased and stored in advance. If an emergency occurs these food supplies are available; if no emergency occurs they will be consumed gradually during the season by the regular employees without the loss resulting from forced sales or the deterioration incident to holding any portion of them over into the succeeding season.

Fire-fighting Organization

From the point of view of its preparedness for a serious fire emergency, I believe that the greatest weakness in our present system is that the most experienced and capable Forest officers are required to give a wholly undue portion of their time to the duties of a quartermaster instead of to the actual direction of fire-fighting work on the ground. The supervisors, deputy supervisors, even the District rangers under the conditions existing last summer, were kept at engaging men, filling orders for groceries and tools, shipping supplies, meeting trains, keep-

ing time, checking foodstuffs and other shipments, approving accounts, hiring teams and pack horses and the like for a large share of their time, when they ought to have been free for giving their strength and effort and thought to the work on the fires. It is like making the general in command of a military campaign his own quartermaster and recruiting officer.

We tried to meet this condition by sending out auditors from the Fiscal Agent's office to prepare and handle accounts in the field; by draining the District Office of clerks, draughtsmen, and other employees down to messengers, for timekeepers, shipping clerks, and men to take charge of the transportation of fire crews in the field, and by using supervisors' clerks and guards and other Forest officers less experienced in fire work for the general quartermaster's duties, filling their places in turn with less experienced temporary employees. This is a problem which demands thorough study and systematization. It can be solved largely by the improved standard of clerks which are being secured for supervisors' offices—just the men who should in a fire emergency jump right into the duties of a quartermaster. If the clerk is not competent for such work, I believe it would be advisable to train up some other member of the force, even a ranger or guard, in the methods of ordering supplies, checking shipments, and preparing accounts in the supervisor's office sufficiently to be able to assume these duties at any point in a fire campaign.

Action along these lines is, I believe, in accord with the principles of "scientific management," since it aims to bring the best brains and experience of the Service to bear directly upon the actual work being done on the fire lines—the work which directly determines the efficiency of the whole organization as measured by its results. It aims to throw the routine duties, the sum total of whose results is simply to keep the machine oiled and fueled, upon competent subordinates. This means direct supervision on the ground instead of paper supervision from the supervisor's desk.

I may have exaggerated this necessity from the vividness with which this defect was brought home to me during the exceptional and prolonged fire campaign which District 1 went through last summer. It was greatly aggravated at that time by the large number of men who had to be employed, the large number of fires to be fought, the large number of shipping points, and the enormous increase generally in all of the work involved in keeping the men on the fire line properly equipped and the routine features of their work provided for. Such as the conditions were I found that unavoidably a comparatively small proportion of the

time of the supervisors and deputies, and even of many of the District rangers, could be given to actual fire work. I found that the most effective way in which the members of the District office could help the local force was in assuming quartermaster's duties at some principal point. To be an effective fire-fighting organization, the Service should be able in an emergency, like the army, to throw into the field a definite quartermaster organization which will leave our best men comparatively free for the direction of the actual field work.

A brief sketch of what to my mind constitutes an ideal fire-fighting organization may be in place. Let us take first the ranger district. Each District, with its force of patrolmen, its own equipment of tool caches and staple food supplies, its pack train—if one is needed—its reserve force to draw upon in the form of per diem guards or a detachment of troops or a string of settlers or lumber camps, and a responsible district ranger in charge, with an assistant who can, if need be, act as quartermaster, should be an independent fire protection unit, dependent upon outside help only under exceptional conditions. This is the ideal which should be worked towards. I do not feel that the Service will be an effective fire-fighting organization until this ideal is reached, since a tremendous loss always occurs whenever an attack upon a fire must wait for men and supplies from an outside source.

Taking the next unit, the National Forest, there should be available for each supervisor either a clerk or a trained ranger or guard, who can act as quartermaster for the Forest whenever the need occurs. The executive staff of the Forest, consisting of the supervisor, his deputy, forest assistant, and other officers not attached to districts, should be very largely foot-loose for field work, directing the foremen of the fire crews, taking hold wherever special assistance is needed and directing the district rangers in adapting their patrol force to the latest exigencies developed by the situation. Either the supervisor or his deputy must keep in sufficiently close touch with headquarters to learn quickly of new developments in the situation—fires in other quarters and the like—but this should seldom require him to remain continuously for any length of time at the office. His best work can be done by directing the work on the larger fires, the location of trenches, the use of back-firing, the size of the force employed, whether too weak or unnecessarily large, and the like. It is just this service which the most experienced and capable men on each Forest should render during a fire emergency, and it is just this which determines the cost of fighting fires and the effectiveness of the work done in protecting the Government property at stake. While the details must be left to district rangers and foremen of fire

crews, periodic supervision from the supervisor or his deputy on the ground is essential to the best work. Many instances occurred last year where timely visits from the supervisor to the rangers in the field, a half day's inspection of the lines, and a few concise instructions as to how the work could be more effectively handled meant success as against failure in bringing a bad fire under control. I feel it essential that the supervisors be in a position to do just this thing.

The District force should resolve itself, during a fire emergency, into a crew of reserve quartermasters, foremen of fire-fighting crews, and the like, with one man always on the job at headquarters to keep in touch with the entire situation in the District, handle transfers of rangers between Forests to make the entire force of the District available where most needed, and keep the general system up to its highest working efficiency. Otherwise all hands should be sent into the danger zone to take hold wherever they can help the supervisors best. Agents need to be placed at labor and supply points from which several different Forests can be equipped. The most effective help can often be rendered by relieving a supervisor at his office of other duties and enabling him to take hold of some of the worst fire situations in the field. As a rule, little can be accomplished at such times by inspection or supervision of the field work by the local officers. It is a time for the District men to take off their coats and take hold of any specific job which confronts them, however insignificant.

A little consideration may be given with profit to the fire record of the Forest Service. For each one thousand acres under administration, 2.86 acres were burned over during 1905, 1.2 acres during 1906, 1.4 acres during 1907, 2.46 acres during 1908, 1.86 acres during 1909, and 25.87 acres during 1910. These figures, of course, do not tell the whole story. They do not indicate how many fires have been put out or how many more acres would have been burned over but for the efforts of the Service. They do not, however, furnish any grounds for self-complacency. The annual burning of one acre out of every 1,000 under administration is a standard which we have not yet reached, but one which I feel should be the minimum with which we should be satisfied. Even this, if all the land burned over were productive timber land, would mean that on an average rotation of one hundred years ten per cent of the forest would be burned over once before reaching maturity.

Aside from some of the suggestions which I have previously made, two general lines of action seem to me to be clearly needed in order to attain this standard of efficiency in fire control. The first of these is continued investigation of all the problems related to fire prevention

and extinguishment by experts who are free from all other duties and thus able to devote their time and efforts exclusively to this problem. This has been begun in two of the Districts. I would like to see one of the best men in every District prosecuting such investigations. The second line of action is also but an extension of what has already been done at many points, but which should, I believe, be enlarged and systematized. This is the instruction of our field personnel in the best methods of fire fighting. Such instruction should be strongly emphasized in the short Forestry courses given for rangers. I believe also that a comprehensive fire-fighting manual should be prepared which can be enlarged and revised from time to time, placed in the hands of every ranger and guard in the Service, and made a part of his duty to master thoroughly. Fire fighting is a matter of scientific management, just as much as silviculture or range improvement. No one recognizes more fully or heartily than I, and I am sure that no one has had occasion to recognize better than I, the character of the work done by the field men of the Service in fighting fires. I am convinced, however, that they and all of us have a deal to learn of this important problem, and that we should be taught in the same manner as the Service is teaching and training its personnel in other lines of work, viz: by expert investigation and systematic instruction based upon the results of the investigation.

Supervisor Adams, of the Ozark Forest, has set a splendid example of what may be accomplished by expert technical study of this problem, particularly in the development of chemical appliances for extinguishing fires. Every phase of the question should be studied in the same intensive manner, including possible "pyrecide" compounds, improved tools, improved methods of communication, fire breaks, and the like, and their results made directly available for the improvement of the fire plans on the respective National Forests and the instruction of the Forest personnel.

FIRE PROBLEM ON THE FLORIDA NATIONAL FOREST

BY I. F. ELDREDGE

(Contributed)

The Florida National Forest is unique among the National Forests of the country in its location, soil, climate, timber, population, and its problems, and the general methods of management in use throughout the Forests of the West can be applied to it but seldom and then only with modifications. This difference is perhaps most clearly shown in the matter of fire protection. In order fully to appreciate the difficulties presented by the fire-protection problem on the Florida Forest, it is necessary to know something of the conditions found on the Forest. The Florida National Forest was formerly the Choctawhatchee and Ocala National Forests. This discussion concerns only the Choctawhatchee division of the Florida National Forest, an area of about 467,000 acres, situated in the extreme western arm of Florida, on Choctawhatchee Bay, Santa Rosa Sound, and East Bay, extending twenty to twenty-four miles into the interior.

It is uniformly but not heavily timbered with longleaf and Cuban pine, with a heavy undergrowth of "blackjack" and turkey oak. The country is nearly level except for a few sandy ridges. It is extremely well watered by several rivers and many creeks and branches, all of which flow into arms of the Gulf of Mexico. The climate is almost semi-tropical, with long, hot summers and short, mild winters. There is an abundance of rainfall, which, however, is not evenly distributed throughout the year, since severe droughts occur in and sometimes last during March, April, and May, and again in October and November. The soil is almost uniformly a deep, white sand, with but little humus in it, and covered by weeds in which there is but little grass.

Nearly 60 per cent of the area included within the Choctawhatchee Division is alienated and now owned by large naval stores companies. These alienated holdings occur as alternate sections, with the exception of a few locations in the southern part of the Forest, where there are several large, solid bodies of National Forest land. The timber owned by the naval stores companies is being exploited for turpentine as rapidly as possible and under the prevailing crude methods. As soon as the timber is exhausted for turpentine it is turned over to the sawmill.

The longleaf and Cuban pine, while not of the class best suited for saw timber, are of good quality for the production of naval stores, and the revenue derived from turpentine permits is the chief source of Forest income. The working plan prescribes the cupping of fourteen new sections each year for the next ten years, and since each section is worked for at least fifteen years before it is exploited for saw timber, the areas being turpentined must be rigidly protected from damage by fire. The operator on private lands does this very successfully by raking around the cupped trees and burning annually in the winter.

One of the most important factors in the fire problem is the population of the Forest. This consists of homesteaders, cattlemen, turpentine operators, and negro turpentine hands. The homesteaders and cattlemen are nearly all native Floridians of the "Cracker" type. They are people who have always lived in their own communities and who have had but little opportunity for advancement, because of the fact that they have been out of touch with the world for many generations. Notwithstanding, however, the many disadvantages under which they live, they are a shrewd people, with many of the sturdy characteristics of the pioneers, and are susceptible of rapid development under proper educational treatment.

The homesteaders and the smaller cattlemen are found all over the Forest, living in small, poorly appointed cabins, generally on homestead claims that were initiated before the creation of the Forest. They make a poor living by working in neighboring turpentine camps, by raising a few head of stock, and through the sale of their homesteads as soon as patent is received. The larger cattle holders who use the Forest reside outside of the Forest on small farms and are people of the same class but in better circumstances.

The turpentine operators are as a rule men who have followed the constantly retreating naval stores industry through the Carolinas, Georgia, and Alabama. While men of ability, they are generally possessed of deep-seated prejudices in regard to the carrying on of their work, and the methods of turpentining now in vogue differ but little from those followed fifty years ago. When once converted, however, to any improvement they are quick to make use of it.

The popular sentiment of the residents within the Forests, in common with nearly all of the people of the South, is unqualifiedly in favor of the annual burning over of the pineries. The homesteader and the cattleman burn the woods to keep down the blackjack undergrowth and to better the cattle range. The turpentine operator burns over his woods annually, after raking around his boxed trees, and at a time when the

burning will do least harm, in order to protect his timber from the later burnings that are sure to occur. He burns also with the idea of keeping the turpentine orchards clear of undergrowth and free from snakes, in order that his negro laborers may gather the gum with ease and safety. The camp hunters, of whom there is a large number during the fall and winter months, set out fires in order to drive out game from the thickets. All of these different classes of people have for a great number of years been accustomed to burning the woods freely and without hindrance of any kind, and it is done without the knowledge or the feeling that they are breaking the laws or in any way doing damage. On the contrary, they all have the most positive belief that burning is necessary and best in the long run.

The turpentine operator burns his woods and all other neighboring woods during the winter months, generally in December, January, or February. The cattleman sets fire during March, April, and May to such areas as the turpentine operator has left unburned. During the summer there are almost daily severe thunder-storms, and many forest fires are started by lightning. In the dry fall months hunters set fire to such "rough" places as may harbor game. It is only by chance that any area of uninclosed land escapes burning at least once in two years.

Longleaf and Cuban pine apparently suffer but little, if any, from the light annual burning of the woods. Even seedlings as young as three years old appear to suffer no damage, although there is no doubt that younger seedlings seldom escape destruction, and the poor reproduction of pine is largely due to the frequent fires that keep the seedlings from getting a start. The undergrowth of oak is burned to the ground, but coppices so profusely that an annual burning is considered necessary to keep it down. The forage grasses are, of course, burned to the ground, but recuperate very rapidly and seem to suffer but very little. In fact, the stockmen claim and believe that the grass is much benefited by the light annual burning.

When an area is left unburned or "rough" for several years, there appears a rank undergrowth of scrub oak and grass with a heavy deposit of unrotted litter. When this "rough" is fired, the damage to seedlings, saplings, and even mature timber is very great, although the mature timber is seldom killed outright. Such a fire creates an intense heat, travels very rapidly, and is very difficult to control; it destroys all seedlings and saplings and kills the grass roots.

In view of the universal belief of the Forest residents in annual burning, because of the fact that the lands controlled by the turpentine operators, which are burned over each year as a matter of business, lie as

alternate sections to Government land throughout the Forest, and because of the limited appropriation for fire protection, total fire protection for all the Forest lands seems out of the question at present. The cost would be enormous, for almost every section of Government land within the Forest is adjoined on its four sides by lands that are privately controlled and burned over as a matter of principle. This means that, roughly speaking, there are nearly eight hundred miles of fire front to fight during the winter; it means that over two hundred sections of land must be patrolled during the early spring to keep the fires set by cattlemen from gaining headway; it means that each section must be patrolled all summer to put out the fires that result from daily thunder-storms, and it means that every camper must be watched in order to prevent fires during the fall. The most disquieting part of the whole situation is that each year of protection from fire makes the fire danger greater, for should the woods be kept "rough" for six or eight years and then burn it would result in almost complete destruction. When lumbering begins, the fire danger will be greatly augmented because of the fact that the private lands scattered throughout the Forest will be logged over first and will be a constant menace to the adjoining Forest lands. I venture to say that a fire-patrol force of thirty men, well organized and equipped, employed the year round, would hardly assure complete protection, and as the years went by the constantly increasing fire danger would demand a larger force.

The advantages to be derived from complete fire protection are many: a better reproduction would be assured in the thin places; the soil would be greatly enriched by the addition of the decayed litter, and the timber would show better and faster growth. The disadvantages are: enormous cost, greatly increased damage whenever a fire occurs; the growth of a rank and worthless undergrowth of scrub oak and the choking out of the range grasses.

If it is impossible to adopt a system that will assure complete and continued fire protection, it will be necessary to inaugurate some system that will offer protection at least to cupped areas, cut-over areas, areas where natural reproduction is to be encouraged, planting areas, sample plots, and ranger stations. Such a system might be outlined as follows: After a thorough survey of the entire Forest, all areas that need protection from fire should be located and their boundaries marked. So far as is possible, these areas should be grouped in order that cost of protection may be reduced; for instance, planting areas, sample plots, areas where natural reproduction is to be encouraged, etc., should all be located adjoining a cupped or logged-over compartment near a ranger station.

The entire group should then be surrounded by a plowed and burned fire line. At some advantageous point in or near the group a lookout tower, connected by telephone with the nearest ranger station, should be established, from which, during the season of greatest fire danger, a constant lookout may be maintained. In addition, during the entire year, rangers and guards should concentrate their fire patrol on the protected areas. The remainder of the Forest lands should be burned annually during the first of January, when the fires are easily controlled and are not at all dangerous. Uncontrolled or unauthorized burning of Forest land should not be allowed at any time. It will not be a difficult matter to obtain the hearty coöperation of most of the settlers within the Forest in carrying out such a plan as this.

The cost of operating such a system of fire protection should be relatively small, since the permanent force will need but little additional aid, and that only during the winter season. Cheap labor can be employed in the watch-towers, and if the telephone system is an efficient one, planting crews, men employed on permanent improvement, etc., may be quickly brought to a fire on the protected areas. One of the advantages of a system as outlined above is that it can be gradually extended, so that eventually, if need be, practically the whole Forest can be protected. This extension can proceed in harmony with increased receipts, change of public sentiment, and, best of all, with the silvicultural needs of the Forest.

WILLIAM RUSSELL DUDLEY.

William Russell Dudley, associate member of the Society of American Foresters, and at one time Vice-President of the American Forestry Association, was born on March 1, 1849, and died in California on June 4, 1911. At the time of his death he was emeritus professor of botany in Stanford University. He was graduated from Cornell in 1874, with the degree of Bachelor of Science, and in 1876 received his master's degree, after which he studied in Strassburg and Berlin. He was a charter member of the scientific honor society of Sigma Xi. His first teaching position was an instructorship in botany at Cornell. From 1876 to 1892 he was assistant professor of botany at Cornell, except for one year, when he served as acting professor of botany in the University of Indiana. In 1892 Professor Dudley became professor of systematic botany at Stanford, and held that position until January, 1911, when failing health caused his retirement on the Carnegie Foundation as professor emeritus.

His studies of trees brought him in contact with work in forestry, and he was for a time a collaborator of the Federal Forest Service. The conifers of California were his special delight, and he knew them more intimately perhaps than any other man. It was mainly through his efforts that the State of California was induced to purchase the forest of redwoods in the Big Basin of Santa Cruz County, and for several years Professor Dudley served on the board which controlled this park and during a portion of the time was secretary. He was a prominent member of the Sierra Club of California, and for several years its director, so that many of his papers were published in the Sierra Club Bulletin. He wrote several monographs on the forest trees of the Pacific slope which appeared in various journals and periodicals, many of them dealing with little known species. He worked for many years on an exhaustive study of the conifers of the West, but at his death the manuscript had not been completed.

To those who knew Professor Dudley, however, the real sorrow at his death was not due so much to the loss of a laborer in the field of science, but to the passing of the man himself. Every one who came in contact with him respected and loved him, and no one could know him without recognizing his innate gentleness and the extreme refinement of his nature. He took a keen intellectual joy in his work, and imparted enthusiasm and aspiration to all his students.

One episode at Stanford University shows the unique esteem in which he was held, and was a tribute to his gentleness and kindness. A professor in the university, a Russian, owned a beautiful and intelligent horse, of which he was passionately fond. He lived an outdoor life and, outside of the classroom, horse and man were almost inseparable, with long rides together through the foothills and mountains that surround the university. The time came, however, when this professor accepted a position in the East, where it would be impossible to take the horse. His attachment to it was so great that he would not sell it, lest it should fall into the hands of persons who would mistreat it. He knew of no one to whom he could give the animal, and so with a heavy heart he started off to a canyon in the foothills determined to shoot his faithful friend in order that it might never know any days less happy than those they had had together. As he was going up a trail he met Professor Dudley coming down with a collection box over his shoulder. Dudley asked where he was bound on what seemed to be a sorrowful mission. The professor told what he intended to do, and Dudley asked if he might not buy the horse. "He is yours! He is yours!" exclaimed the Russian, delighted. "I give him to you! You are the only man in all the world who is worthy of him, the only one with whom I would gladly trust him!"

B. A.

A BIBLIOGRAPHY OF THE SOUTHERN APPALACHIAN AND WHITE MOUNTAIN REGIONS

COMPILED BY HELEN E. STOCKBRIDGE

OUTLINE OF SUBJECTS

1. National forest movement.
2. Topography and resources in general.
3. Botany.
4. Forests and forestry; forest influences.
5. Water resources.
6. Climatology.
7. Geology.
8. Mines and mineral resources.
9. Soils.

NOTE.—In compiling the references to the natural resources of these regions, only such books and articles as deal exclusively with the parts of the country in which the White and Southern Appalachian Mountains lie have been included. Further information along these lines may be found in the general botanies, geologies, etc., of the United States, and in atlases, geographies, and encyclopedias, under the names of the states concerned.

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CONSTITUTION, AS AMENDED TO DATE

ARTICLE I

NAME

The name of this Society shall be The Society of American Foresters.

ARTICLE II

OBJECT

The object of this Society shall be to further the cause of forestry in America by fostering a spirit of comradeship among foresters; by creating opportunities for a free interchange of views upon forestry and allied subjects; and by disseminating a knowledge of the purpose and achievements of forestry.

ARTICLE III

MEMBERSHIP

Section 1. Members may be Active, Associate, or Honorary.

Sec. 2. Active members shall be professional foresters of achievement, whose field of work lies within the United States or its possessions.

Sec. 3. Associate members shall be chosen from those gentlemen, not professional foresters, who have rendered distinguished service to the cause of American forestry. They may attend all meetings of the Society, may take part in its discussions, but shall not be entitled to vote.

Sec. 4. Honorary members shall be chosen from professional foresters of achievement whose field of work lies outside of the United States and its possessions. They may attend all meetings of the Society, may take part in its discussions, but shall not be entitled to vote.

Sec. 5. Any active member may propose names of candidates for Active, Associate, or Honorary membership. Such names shall be submitted in writing to the Committee on Admissions, which shall report to the Society the names which it approves. Votes upon the names of candidates approved by the Committee on Admissions may be cast either in person or by letter. An adverse vote of one-tenth of the members voting, shall exclude from membership, providing that not less than five adverse votes are cast. Each proposal for membership shall be accompanied by a brief biographical sketch, giving the qualifications of the candidate for admission to the Society.

Sec. 6. Charges of conduct unbecoming a member may be preferred by any Active member. Such charges shall be made in writing to the Committee on Admissions, which shall without delay investigate them and report to the Society. A two-thirds vote of the Active members shall be necessary to suspend or expel.

ARTICLE IV

OFFICERS

Section 1. The officers of this Society shall be a President, a Vice-President, a Secretary, and a Treasurer.

Sec. 2. The officers shall be elected, as hereinafter provided in Article V, Section 2, from the Active members by letter-ballot at the first executive meeting of the calendar year, and shall serve one year, or until their successors are elected.

Sec. 3. The President shall preside at the meetings of the Society, shall appoint the committees hereinafter designated, and shall perform all other duties incident to his office.

Sec. 4. In the absence of the President, the Vice-President shall preside at the meetings of the Society.

Sec. 5. The Secretary shall keep the minutes of the Society, shall conduct its correspondence, shall announce its meetings, and shall be custodian of its permanent records.

Sec. 6. The Treasurer shall collect all moneys due the Society and have custody of all moneys received. He shall deposit and expend the latter only in such manner as the Executive Committee shall direct.

ARTICLE V

COMMITTEES

Section 1. The following standing committees, composed of Active members, shall be elected by the Society or appointed by the President, as hereinafter specified, at or as soon as possible after each annual meeting: Executive Committee, Committee on Admissions, Committee on Meetings, and an Editorial Board.

Sec. 2. The Executive Committee shall be elected by letter-ballot, shall consist of five (5) members, and shall choose its own chairman. Three (3) members shall constitute a quorum. This Committee shall control all funds, and shall perform any other executive duties delegated to it by the Society. The Executive Committee, before each annual meeting, shall appoint a Nominating Committee of three (3) Active members of the Society, whose duty it shall be to make not less than two (2) nor

more than three (3) nominations for each of the officers, and not less than ten (10) nor more than fifteen (15) nominations for members on the Executive Committee. These nominations shall be submitted to the Active membership of the Society not more than eight (8) nor less than four (4) weeks before the annual meeting. Other nominations, if signed by at least ten (10) members and presented to the Secretary in writing at least four (4) weeks before the annual meeting, shall also be submitted to the membership on the official ballot. The candidate receiving the highest number of votes for each office, and the five (5) candidates receiving the highest number of votes for membership on the Executive Committee, shall be declared elected. The Executive Committee shall have the power to fill any vacancies occurring in their number or in any office.

Sec. 3. The Committee on Admission shall be appointed by the President, shall consist of five (5) members, and shall choose its own chairman. It shall consider all names proposed for membership and shall recommend for election only those candidates who in its judgment are qualified for admission to the Society. It shall forward through the Secretary the names and biographical sketches of such candidates, and any other necessary information, to all Active members, who shall vote upon them either by letter or in person. A vote upon such candidates shall be taken at the first executive meeting after the expiration of one month from the date upon which their names were forwarded to Active members. The names and papers of those whom the Committee does not recommend for election shall be returned to the members by whom they were proposed. Appeal from the Committee on Admissions may be taken to the Society, through the written demand of one-fourth of the Active members, addressed to the President. The Committee on Admissions shall also, as provided in Article III, Section 6, investigate charges preferred against members and report upon them to the Society.

Sec. 4. The Committee on Meetings shall be appointed by the President, shall consist of three (3) members, and shall choose its own chairman. It shall elect the speakers, subjects, and dates for the meetings of the Society.

Sec. 5. The Editorial Board shall be appointed by the President, and shall consist of nine (9) members. Within this Board there shall be appointed an Executive Committee, one member of which shall be designated by the President as Editor-in-Chief. The Board shall decide on the regular policy of the publication. The Executive Committee shall consider papers read before the Society, or otherwise submitted to it, shall approve or reject them for publication, and shall transact the business necessary to that end.

ARTICLE VI

MEETINGS

Section 1. The Society shall hold an annual meeting, executive meetings, and open meetings.

Sec. 2. The annual meeting shall be held at a place and on a date to be designated jointly by the Executive Committee and the Committee on Meetings. It shall be for the transaction of business and for the presentation and discussion of professional papers.

Sec. 3. Executive meetings shall be open to members only, and shall be held at the call of the President, or, in his absence, at that of the Secretary. They shall be for the transaction of business and the discussion of any subject selected by the Committee on Meetings.

Sec. 4. Open meetings may be attended by members and by guests of the Society, and shall be held as directed by the Committee on Meetings. The Society may hold such field meetings as the Society or Committee on Meetings may direct.

Sec. 5. A quorum shall consist of seven (7) Active members.

Sec. 6. Upon the order of either the Executive Committee or a majority of the Active members present at any meeting, any question shall be submitted to the membership for decision by letter-ballot.

ARTICLE VII

AFFILIATED ORGANIZATIONS

Section 1. Any local forestry society or club whose membership includes two or more Active members of the Society of American Foresters may petition the Society in writing, through such members, for the enrollment of the Society or Club as an affiliated organization. If, in the judgment of the Executive Committee, the membership and aims of the organization are of sufficiently high professional character, the Committee shall grant said petition and the organization be enrolled as the

....,
(Name of organization)

affiliated with the Society of American Foresters.

Sec. 2. Affiliated organizations shall determine the qualifications for membership in them, but no rights or privileges belonging to Active members of the Society of American Foresters shall be attained merely by membership in an affiliated organization.

Sec. 3. As a condition of affiliation with the Society, each affiliated

organization shall, as a whole, pay the regular annual dues of $3, and shall receive one copy of all publications and communications of a public nature intended for Active members. The organization shall also elect one or more of the Active members of the Society, in good standing, who shall represent the Society officially and shall handle all business and correspondence between the Society and the affiliated organization.

Sec. 4. Papers delivered before any affiliated organization shall be the property of that organization and may be published in its official organ. The affiliated organization may offer for publication, in the Proceedings of the Society of American Foresters, papers of a high professional or technical nature which have not already been published. These papers shall be subject to the approval of the Editorial Board, and if not approved for publication shall be returned to the organization in which they originated.

Sec. 5. The Executive Committee shall have the right at any time to rescind the authorization for any affiliated organization and to terminate its connection with the Society.

ARTICLE VIII

SECTIONS

Section 1. To carry out more effectively the aims of the Society, sections may be established wherever there are enough Active members to form a strong local organization. The formation of such sections may be authorized by the Executive Committee upon the written petition of ten or more Active members. Only Active members of the Society shall be eligible to membership in a Section. A Section shall be known as the

....

(Name of place)

Section of the Society of American Foresters.

Sec. 2. The officers of each Section shall consist of a Chairman and a Secretary, and such others as may be found necessary.

Sec. 3. Any Section may, subject to the approval of the Executive Committee, adopt for its own government such By-Laws as it may find expedient, provided that no part thereof shall conflict with the Constitution of the Society.

Sec. 4. No money from the general funds of the Society shall be appropriated or used for the expenses of a Section.

Sec. 5. Papers and discussions presented before any Section shall be the property of the Society, and the Secretary of the Section shall for-

ward a copy to the Editorial Board. The Editorial Board shall have full right to publish in the Proceedings of the Society such papers as it may approve for publication. Papers and discussions not approved for publication by the Editorial Board shall be returned to the Section in which they originated.

Sec. 6. The Executive Committee shall have the right at any time to rescind the authorization of any Section and to terminate its existence.

ARTICLE IX

PUBLICATION

Section 1. The Society shall publish such papers read before or contributed to it, and in such form, as the Editorial Board shall approve.

Sec. 2. The publications shall be free of charge to all Active and Honorary members of the Society.

ARTICLE X

DUES

Section 1. The annual dues of Active members shall be three (3) dollars. Dues shall be payable in advance upon the first day of January, except that the dues of newly elected members for the year in which they are elected shall be payable from the date of their election.

Sec. 2. Associate and Honorary members shall pay no dues.

ARTICLE XI

AMENDMENTS

This Constitution may be amended by a three-fourths (¾) vote of the members voting by letter-ballot or in person at an executive meeting of the Society, provided the proposed amendments have been submitted to all Active members at least four (4) weeks in advance.

MEMBERSHIP ROLL OF THE SOCIETY OF AMERICAN FORESTERS, 1911

Associate Members

James Barry Adams.............................Washington, D. C.
Forest Service, U. S. Dept. of Agriculture

George Patrick Ahern.................................Manila, P. I.
(U. S. M. A., 1882); LL.B. (Yale, 1895)
Chief of Bureau of Forestry, War Department

Christopher Columbus Andrews.....................St. Paul, Minn.
Chief Fire Warden, State of Minnesota

Charles Edwin Bessey...............................Lincoln, Nebr.
B.S. (Michigan Agricultural College, 1869); M.S. (Michigan Agricultural College, 1872); Ph.D. (Iowa, 1879); LL.D (Iowa, 1898)
Professor of Botany, University of Nebraska

Harold Scofield Betts...............................Madison, Wis.
M.E. (Stevens Institute of Technology, 1900)
Forest Service, U. S. Dept. of Agriculture

Frank Swett Black....................................Troy, N. Y.
A.B. (Dartmouth, 1875); LL.D. (Dartmouth, 1898)

Edward Augustus Bowers.......................New Haven, Conn.
B.A. (Yale, 1879); LL.B. (Yale, 1881)
Lecturer in Forest Law, Yale Forest School

William Henry Brewer...............................(Deceased)
Ph.B. (Yale, 1852); A.M. (Yale, 1859); Ph.D. (Washington and Jefferson, 1880); LL.D. (Wesleyan, 1903); (Yale, 1903)

Howard Stanley Bristol..............................Madison, Wis.
Ph.B. (Sheffield Scientific School, 1902); Ph.D. (Yale University, 1905)
Forest Service, U. S. Dept. of Agriculture

Eugene Sewell Bruce..........................Washington, D. C.
Forest Service, U. S. Dept. of Agriculture

Grover Cleveland......................................(Deceased)
LL.D (Princeton, 1897)

McGarvey Cline....................................Madison, Wis.
B.S. (Purdue University, 1904)
Forest Service, U. S. Dept. of Agriculture

Frederic Vernon Coville..........................Washington, D. C.
A.B. (Cornell, 1887)
Botanist, U. S. Dept. of Agriculture

William Russell Dudley..................................(Deceased)
B.S. (Cornell, 1874); M.S. (Cornell, 1876)

Nathaniel Hillyer Eggleston...................Jamaica Plain, Mass.

Simon Bolivar Elliot...............................Harrisburg, Pa.
Member Pennsylvania Forestry Reservation Commission

Charles Edward Faxon......................Jamaica Plain, Mass.
S.B. (Harvard, 1867); A.M. (Harvard, 1897)
Instructor, Arnold Arboretum

Frank A. Fenn......................................Kooskia, Idaho
Forest Service, U. S. Dept. of Agriculture

William Freeman Fox....................................(Deceased)

David Rowland Francis..............................St. Louis, Mo.
B.A. (Washington, 1870)

Robert Wilkinson Furnas........................Brownville, Nebr.

Henry Gannett....................................Washington, D. C.
S.B. (Harvard, 1869); M.E. (Harvard, 1870); LL.D. (Bowdoin, 1899)
Geographer, U. S. Geological Survey

Wolcott Gibbs ....(Deceased)
A.B. (Columbia, 1841); A.M. (Columbia, 1844); M.D. (College of Physicians and Surgeons, New York, 1843); LL. D. (Columbia, 1873; Harvard, 1888; Columbian, 1895)

Arnold Hague.....................................Washington, D. C.
Ph.B. (Yale, 1863); D.Sci. (Columbia, 1900)
Geologist, U. S. Geological Survey

Benjamin Harrison ....(Deceased)
B.A. (Miami, 1852)

William Kendrick Hatt.............................Lafayette, Ind.
B.A. (University of New Brunswick, 1887); C.E. (Cornell, 1891); M.A. (University of New Brunswick, 1898); Ph.D. (University of New Brunswick, 1901)
Forest Service, U. S. Dept. of Agriculture

Charles Holmes Herty............................Chapel Hill, N. C.
Ph.B. (University of Georgia, 1886); Ph.D. (Johns Hopkins University 1890)
Professor of Chemistry, University of North Carolina

Ethan Allen Hitchcock....................................(Deceased)
LL.D (Mobile, 1902)

Joseph Austin Holmes............................Washington, D. C.
B.A. (Cornell, 1881)
Director, U. S. Bureau of Mines

Andrew Delmar Hopkins..........................Washington, D. C.
Ph.D. (West Virginia, 1893)
Bureau of Entomology, U. S. Dept. of Agriculture

John George Jack.............................Jamaica Plain, Mass.
Instructor in Forestry, Harvard University

Morris Ketchum Jesup....................................(Deceased)
LL.D. (Princeton, 1902)

L. F. Kneipp....................................Washington, D. C.
Forest Service, U. S. Dept. of Agriculture

Otto Luebkert...................................Washington, D. C.
1341 *G Street N. W.*

T. P. Lukens..Pasadena, Cal.

M. J. McVean..............................Tuscola, Saskatchewan

Clinton Hart Merriam...................................Lagunitas, Cal.
B.S. (Yale, 1877); M.D. (College of Physicians and Surgeons, New York, 1870)
Consulting Biologist, U. S. Dept. of Agriculture

Haven Metcalf...................................Washington, D. C.
A.B. (Brown, 1896); A.M. (Brown 1897); Ph.D. (Nebraska, 1903)
Pathologist, U. S. Dept. of Agriculture

Charles Mohr ....(Deceased)
Ph.D. (Alabama, 1890)

Julius Sterling Morton...................................(Deceased)
A.B. (Union, 1854); LL.D. (Williams, 1896)

Frederick Haynes Newell........................Washington, D. C.
B.S. (Massachusetts Institution of Technology, 1885)
Director, Reclamation Service

John Willock Noble.................................St. Louis, Mo.
B.A. (Yale, 1851); LL.D. (Miami, 1889; Yale, 1891)

James Warren Pinchot....................................(Deceased)

Theodore Roosevelt................................Oyster Bay, N. Y.
A.B. (Harvard, 1880); LL.D. (Columbia, 1899; Hope, 1901; Yale, 1901; Howard, 1902; Northwestern, 1903)

Charles Sprague Sargent........................Jamaica Plain, Mass.
A.B. (Harvard, 1862)
Director, Arnold Arboretum

Alexander S. Shaw....................................Portland, Ore.

Herbert Augustine Smith........................Washington, D. C.
B.A. (Yale, 1889); Ph.D. (Yale, 1897)
Forest Service, U. S. Dept. of Agriculture

Volney Morgan Spalding..............................Tucson, Ariz.
A.B. (Michigan, 1873); Ph.D. (Leipsic, 1894)
Desert Laboratory, Carnegie Institution

George Washington Vanderbilt......................Biltmore, N. C.

Charles Doolittle Walcott........................Washington, D. C.
LL.D. (Hamilton, 1897; Johns Hopkins, 1902; Pennsylvania, 1903)
Secretary of Smithsonian Institution

John Breckenridge Waldo..............................Macleay, Ore.

William Seward Webb................................Shelburne, Vt.
M.D. (College of Physicians and Surgeons, New York, 1875)

Philip P. Wells..................................Washington, D. C.
B.A. (Yale, 1899); Ph.D. (Yale, 1900)
Law Officer, U. S. Reclamation Service

William Collins Whitney...................(Deceased Feb. 2, 1904)
B.A. (Yale, 1863); LL.D. (Yale, 1889)

George Patten Whittlesey........................Washington, D. C.
B.A. (Yale, 1878); LL.B. (Columbian, 1881)
900 *F Street N. W.*

Benjamin Lawton Wiggins.............................(Deceased)
B.A. (University of the South, 1880); M.A. (University of the South 1882); LL.D. (Trinity [Conn.], 1899; St. John's [Md.], 1902)

James Wilson....................................Washington, D. C.
Secretary of Agriculture

George Washington Woodruff.......................Honolulu, Hawaii
B.A. (Yale, 1889); LL.B. (Pennsylvania, 1895)
U. S. District Judge, District of Hawaii

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Bentley, John, Jr.................Forest Service, Denver, Colo.
Besley, F. W......................Johns Hopkins Univ., Baltimore, Md.
Bradfield, Wesley................224 Grant Ave., Santa Fe, N. Mex.
Braniff, Edward A...............Forest Service, Portland, Ore.
Bruins, J. Frank..................Forest Service, Pocatello, Idaho.
Bryant, Ralph Clement...........Yale Forest School, New Haven, Conn.
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Cheyney, Edward G..............Univ. of Minnesota, St. Paul, Minn.
Chittenden, Alfred K.............Indian Office, Washington, D. C.
Clapp, Earle H...................Forest Service, Washington, D. C.
Clark, Ernest D..................Forest Service, Washington, D. C.
Clark, E. T......................Forest Service, Seattle, Wash.
Clark, Dr. Judson F.............403 Crown Bldg., Vancouver, B. C.
Clement, George E...............275 Warren St., Boston, Mass.
Clifford, Edward C...............Forest Service, Missoula, Mont.
Cohoon, Anson E.................Forest Service, Eugene, Ore.
Cook, Arthur M..................Forest Service, Fraser, Colo.
Coolidge, Philip T...............Colorado School of Forestry, Colorado Springs, Colo.
Cooper, A. W....................Sec'y Western Pine Mfrs. Asso., Hutton Bldg., Spokane, Wash.
Cox, William T..................State Forester, St. Paul, Minn.
Curran, Hugh M..................Bureau of Forestry, Manila, P. I.
Dana, Samuel Trask..............Forest Service, Washington, D. C.
Detwiler, Samuel B..............Chestnut Tree Blight Comm., 1112 Morris Bldg., Phila., Pa.
Drake, Willard M................Forest Service, Flagstaff, Ariz.
Du Bois, Coert..................Forest Service, San Francisco, Calif.
Dunlap, Frederick................Forest Service, Madison, Wis.
Dunston, Clarence E.............Forest Service, St. Anthony, Idaho.
Eldredge, Inman F...............Forest Service, Pensacola, Fla.
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Ferguson, John A................Univ. of Missouri, Columbia, Mo.
Fernow, B. E....................Univ. of Toronto, Toronto, Canada.
Fetherolf, James M..............Forest Service, Ogden, Utah.
Filley, Walter O.................Conn. Agr. Exp. Sta., New Haven, Conn.
Fisher, Richard T...............Harvard Forest School, Petersham, Mass.
Foley, John.....................413 Oak Lane, Wayne, Pa.
Foster, Harold Day..............Forest Service, Medford, Ore.

Foster, John Harold..............New Hampshire Agr. College, Durham, N. H.
Foxworthy, Fred W...............Bureau of Science, Manila, P. I.
Fromme, Rudo L...................Forest Service, Grants Pass, Ore.
Frothingham, Earl H.............Forest Service, Washington, D. C.
Gaskill, Alfred...................State House, Trenton, N. J.
Gaylord, Frederick A.............Forest, Fish, and Game Commission, Albany, N. Y.
Gifford, John C..................Cocoanut Grove, Dade Co., Fla.
Graff, Herbert....................Forest Service, Austin, Nevada.
Graves, Henry S..................Forest Service, Washington, D. C.
Greeley, William B...............Forest Service, Washington, D. C.
Griffith, E. M....................505 S. Hamilton St., Madison, Wis.
Guthrie, John D..................Forest Service, Springerville, Ariz.
Hale, Harry M...................Forest Service, Okanogan, Wash.
Hall, R. Clifford.................Forest Service, Washington, D. C.
Hall, William L..................Forest Service, Washington, D. C.
Harris, Philip T.................Forest Service, Tacoma, Wash.
Hawes, Austin F.................State Forester, Burlington, Vt.
Hawley, Ralph C.................Yale Forest School, New Haven, Conn.
Hatton, J. H.....................Forest Service, San Francisco, Calif.
Hill, Cary L.....................Univ. of Mich., Ann Arbor, Mich.
Hirst, Edgar C..................State Forester, Concord, N. H.
Hodge, William C................Forest Service, San Francisco, Cal.
Hodson, Elmer R.................Forest Service, Ogden, Utah.
Holmes, John S..................Chapel Hill, N. C.
Homans, G. Morris...............State Capitol, Sacramento, Calif.
Hosmer, Ralph S.................Supt. of Forestry, Box 207, Honolulu, Hawaii.
Howard, William G..............Forest, Fish, and Game Commission, Albany, N. Y.
Imes, Richard P.................Forest Service, Custer, S. Dak.
Judd, Charles S..................Commissioner of Public Lands, Honolulu, Hawaii.
Keach, John E...................Forest Service, Missoula, Mont.
Kelleter, Paul D.................Forest Service, Deadwood, S. Dak.
Kellogg, Royal S.................Northern Hemlock and Hardwood Mfrs. Asso., Wausau, Wis.
Kent, W. H. B...................Casanovia, N. Y.
Kiefer, Francis...................Forest Service, Harrison, Ark.

Kinney, David G................Forest Service, Missoula, Mont.
Kirkland, Burt P................Forest Service, Seattle, Wash.
Klemme, Wilhelm................Bureau of Forestry, Manila, P. I.
Knechtel, A......................Forestry Branch, Dept. Interior, Ottawa, Canada.
Koch, Elers......................Forest Service, Missoula, Mont.
Kümmel, Julius F................Forest Service, Portland, Ore.
Kupfer, Carl A..................Forest Service, San Francisco, Calif.
Leavitt, Clyde...................Forest Service, Washington, D. C.
Lovejoy, P. S., Jr................Forest Service, Olympia, Wash.
Lull, Gerard B..................Sacramento, Calif.
Lyford, Charles A...............Board of Trade Bldg., Montreal, Can.
MacDonald, Gilmore B...........Iowa Exp. Station, Ames, Iowa.
MacDuff, Nelson Ferris...........Forest Service, Grants Pass, Ore.
Mackaye, Benton.................Boston (Cambridge), Mass.
McLean, Forman R..............Forest Service, Ogden, Utah.
Margolin, Louis..................403 Crown Bldg., Vancouver, B. C.
Marston, Roy L...................Skowhegan, Me.
Mason, David T.................Forest Service, Anaconda, Mont.
Mast, William H................Forest Service, Denver, Colo.
Mattoon, Wilbur R...............Forest Service, Albuquerque, N. M.
Maule, W. M......................Forest Service, Gardnerville, Nev.
Mell, Clayton D..................Forest Service, Washington, D. C.
Merrill, H. G....................Forest Service, Santa Barbara, Cal.
Miller, Francis G................Univ. of Washington, Univ. Station, Seattle, Wash.
Moody, Frank B.................Rhinelander, Wis.
Moon, Frank F..................Mass. Agric. Col., Amherst, Mass.
Moore, Barrington...............Forest Service, Washington, D. C.
Moore, Sydney L................Forest Service, Denver, Colo.
Moore, Walter M................Forest Service, Santa Barbara, Cal.
Morrell, Fred W.................Forest Service, Denver, Colo.
Morrill, Walter J................Forest Service, Monte Vista, Colo.
Mulford, Walter..................College of Agriculture, Cornell Univ., Ithaca, N. Y.
Munger, T. T...................Forest Service, Portland, Ore.
Murdoch, John, Jr................Forest Service, Wagon Wheel Gap, Colo.
Murphy, Louis S.................Forest Service, Washington, D. C.
Neel, Harry C...................Belle Mead, N. J.
Nelson, John M., Jr..............P. & R. C. & I. Co., Pottsville, Pa.

Olmsted, F. E....................141 Milk St., Boston, Mass.
Oman, Andrew E................Forest Service, Weiser, Idaho.
Patterson, Allan B..............Forest Service, Hot Springs, Calif.
Pearson, G. A....................Forest Service, Flagstaff, Ariz.
Peavy, George W................Oregon Agric. Col., Corvallis, Ore.
Peck, Allen S....................Forest Service, Albuquerque, N. M.
Peters, James Girvin.............Forest Service, Washington, D. C.
Pettis, Clifford R.................Forest, Fish, and Game Commission, Albany, N. Y.
Pinchot, Gifford..................1615 R. I. Ave., Washington, D. C.
Piper, William B.................Forest Service, Au Sable, Mich.
Plummer, Fred G................Forest Service, Washington, D. C.
Potter, Albert F..................Forest Service, Washington, D. C.
Pratt, M. B.......................Forest Service, Nevada City, Calif.
Preston, John F..................Forest Service, Missoula, Mont.
Price, Overton W................Colorado Bldg., Washington, D. C.
Ramskill, Jerome H..............Forest Service, Delta, Colo.
Read, A. D........................Forest Service, Albuquerque, N. M.
Recknagel, Arthur B.............Forest Service, Albuquerque, N. M.
Redington, Paul G...............Forest Service, Northfork, Calif.
Reed, Franklin W................Forest Service, Washington, D. C.
Reynolds, R. V. R...............Forest Service, Ogden, Utah.
Riley, Smith......................Forest Service, Denver, Colo.
Ringland, Arthur C..............Forest Service, Albuquerque, N. M.
Rogers, Robert L.................Forest Service, Albuquerque, N. M.
Roth, Filibert....................Univ. of Michigan, Ann Arbor, Mich.
Rothery, Julian E................Forest Service, McCall, Idaho.
Rothkugel, Max..................Forest Service, Ketchikan, Alaska.
Sackett, Homer S................Forest Service, Fisher Bldg., Chicago, Ill.
Schenck, Dr. C. A................Biltmore, N. C.
Schwarz, G. Frederick............1223 Beacon St., Brookline, Mass.
Scott, Charles A..................Agric. College, Manhattan, Kan.
Shepard, William C..............Broad St. Sta., Philadelphia, Pa.
Sherfesee, William F.............Bureau of Forestry, Manila, P. I.
Sherrard, Thomas H..............Forest Service, Portland, Ore.
Shinn, Charles H.................Forest Service, North Fork, Calif.
Siecke, Eric O...................Forest Service, Wallowa, Ore.
Silcox, Ferdinand A..............Forest Service, Missoula, Mont.
Smith, Charles Stowell...........Forest Service, San Francisco, Calif.

Smith, Clinton G................	Forest Service, Logan, Idaho.
Smith, Stanton G................	Forest Service, Williams, Ariz.
Sponsler, Olenus L...............	Univ. of Nebraska, Lincoln, Neb.
Spring, Samuel N.................	Agric. Ex. Sta., New Haven, Conn.
Stabler, Herbert O...............	Forest Service, Portland, Ore.
Stephen, John W.................	Forest, Fish, and Game Commission, Albany, N. Y.
Sterling, Ernest A...............	Broad St. Sta., Philadelphia, Pa.
Sterrett, William D..............	Forest Service, Washington, D. C.
Stuart, Robert Y.................	Forest Service, Missoula, Mont.
Sudworth, George B..............	Forest Service, Washington, D. C.
Tiemann, Harry D...............	Forest Service, Madison, Wis.
Tierney, Dillon P................	Asst. State Forester, St. Paul, Minn.
Tillotson, C. R....................	Forest Service, Washington, D. C
Tompkins, H. J..................	Forest Service, San Francisco, Cal.
Toumey, J. W....................	Yale Forest School, New Haven, Conn.
Tower, Gordon E................	Salem, Oregon.
Viles, Blaine S..................	Augusta Trust Bldg., Augusta, Me.
Von Bayer, William H............	Indian Office, Washington, D. C.
Waha, Alpheus O................	Forest Service, Albuquerque, N. M.
Warner, Joseph De Witt..........	Forest Service, Livingston, Mont.
Weber, William Hoyt.............	Munson-Whitaker Co., N. Y. City.
Weigle, William G...............	Forest Service, Ketchikan, Alaska.
Weiss, Howard F................	Forest Service, Madison, Wis.
Wentling, J. P..................	Univ. of Minn., St. Paul, Minn.
Wernstedt, Lage von.............	Forest Service, Portland, Ore.
Wilber, Charles P................	State House, Trenton, N. J.
Williams, Asa S..................	Care Allis-Chalmers-Bullock, Ltd., Montreal, Canada.
Wirt, George H..................	Dept. of Forestry, Harrisburg, Pa.
Woodbury, Truman D............	Forest Service, San Francisco, Calif.
Woodward, Karl W...............	Forest Service, Washington, D. C.
Woolsey, Theodore S., Jr..........	Forest Service, Albuquerque, N. M.
Worthley, Irving T...............	Mont Alto, Pa.
Ziegler, Edwin A................	Mont Alto, Pa.
Zon, Raphael....................	Forest Service, Washington, D. C.